ARVOR-DEEP FLOAT – 33-16-028_UTI

USER MANUAL

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USER MANUAL

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16/02/15	1	Minor modifications	JS
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18/12/15	3		JS
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24/01/17	5	Near surface & In air acquisition mode added	JS
13/10/17	6	Ice detection added	DN
12/12/17	7	CTD & CTDO packet format modification	JS
06/11/18	8	Adjusting of Ice parameters default values	DN

1 INTRODUCTION

ARVOR-DEEP is a subsurface profiling float developed jointly by IFREMER and nke instrumentation. Since January 1st, 2009 **nke** has integrated profiling floats activity and is now in charge of ARVOR-DEEP manufacturing and development in industrial partnership with IFREMER.

The ARVOR-DEEP float described in this manual is designed for the ARGO Program. This international program will be a major component of the Global Ocean Observing System (GOOS). An array of 3,000 free-drifting profiling floats is planned for deployment in 2004. These floats will measure the temperature and salinity of the upper 2,000 meters of the ocean, allowing continuous monitoring of the ocean's climate.

All Argo measurements will be relayed and made publicly available within hours after collection. The data will provide a quantitative description of the evolving state of the upper ocean and the patterns of ocean climate variability, including heat and freshwater storage and transport. It is expected that ARGO data will be used for initialization of ocean and coupled forecast models, and for dynamic model testing. A primary focus of Argo is seasonal to decadal climate variability and predictability.

After launch, ARVOR-DEEP's mission consists of a repeating cycle of descent, submerged drift, ascent and data transmission. During these cycles, ARVOR-DEEP dynamically controls its buoyancy with a hydraulic system. This hydraulic system adjusts the density of the float causing it to descend, ascend or hover at a constant depth in the ocean. The user selects the depth at which the system drifts between descent and ascent profiles. ARVOR-DEEP continually samples the pressure at this drift depth and maintains that depth within approximately 30m.

After the submerged drift portion of a cycle, the float proceeds to the depth at which the ascending profile is to begin. The ascent profile starting depth (typically the ARGO-selected depth of 2,000m) is not necessarily the same as the drift depth.

During its mission, ARVOR-DEEP collects measurements of 3 or 4 parameters - salinity, temperature and depth (CTD) with optional dissolved oxygen - and saves them in its memory. These measurements can be made during the float descent (descent profile), during the submerged drift period (Lagrangian operation) and during the ascent (ascent profile).

After each ascent, ARVOR-DEEP transmits its saved data to the satellites of the Iridium system. The volume of data is reduced using a compression algorithm in order to reduce the number of Iridium messages ot transmit. The Iridium system calculates the float's position during its stay on the sea surface.

This manual describes the ARVOR-DEEP float, how to use it and safety precautions to be observed during handling.

In 2016, nke developed new firmware evolutions for “In air” measurement, and added Ice detection function.

Please read this manual carefully to ensure that ARVOR-DEEP functions as intended.

Overview of the present manual’s contents:

- Chapter 2 contains the instructions necessary for the personnel in charge of the deployment
- Chapter 3 describes the components of ARVOR-DEEP; it is intended for those who want a more in-depth understanding of ARVOR-DEEP
- Chapter 4 describes the mission of ARVOR-DEEP
- Chapter 5 describes the various parameters
- Chapter 6 describes the various IRIDIUM messages
- Chapter 7 presents the technical specifications
- Chapter 8 provides explanations about the operation of ARVOR-DEEP
- Chapter 9 specifies the elements of the constraints limited to the transport of Lithium batteries.

2 OPERATING INSTRUCTIONS

The following instructions tell you how to handle, configure, test and launch the ARVOR-DEEP float. Please read these instructions carefully and follow them closely to ensure your ARVOR-DEEP float functions as intended.

2.1 Handling precautions

ARVOR-DEEP is designed to withstand submersion at great depths for long periods of time (up to five years). This remarkable specification in oceanographic instrumentation is possible thanks to the protection of the casing by coating. This coating is sensitive to impact.

NOTE: Take precautions to preserve the coating during handling. Remove the float from its packing only when absolutely necessary.

NOTE: Regulations state that ARVOR-DEEP must not be switched on during transport.

2.2 Acceptance pests

Immediately upon receipt of the ARVOR-DEEP float, you should test it to confirm that it is complete, correctly configured and has not been damaged in shipment. If your ARVOR-DEEP float fails any of the following tests, you should contact **nke instrumentation**.

2.2.1 Inventory

The following items should be supplied with your ARVOR-DEEP float:

- The present user manual.
- A test sheet.
- Quickstart & Deployment checklist

NOTE: Disassembly of the float voids the warranty.

Check that all of the above items are present. If any are missing, contact **nke-instrumentation**.

2.2.2 Physical inspection

Upon the opening of the transport casing, visually inspect the float's general condition: Inspect the transport container for dents, damage, signs of impact or other signs that the float has been mishandled during shipping. Inspect the CTD sensor, antenna, hull, housing around the lower bladder for dents or any other signs of damage

NOTE: Ensure the magnet is in place against the hull (on ON/OFF position), meaning that float is switched OFF.

2.3 Default parameters

Notwithstanding special instructions given to NKE during the ARVOR-DEEP preparation stage, the following set of parameters is applied: **section 5**.

If these parameters are not appropriate, the user can change them himself by following the instructions.

2.3.1 ARGO Identification

The user is responsible for contacting the AIC in order to obtain the WMO number which will identify the ARVOR-DEEP's mission

2.3.2 Decoding

The CORIOLIS project team (IFREMER) is able to assist the teams that use ARVOR-DEEP for data processing.

Nke can provide light PC software for manual data decoding. Contact **nke-instrumentation**.

2.4 Launching

Following is what you should do to launch the ARVOR-DEEP float.

2.4.1 Test the float and arm the mission

Before you take ARVOR-DEEP on deck for deployment, we recommend that you repeat all of the tests described in section 2.5.8. This will ensure that the float is functioning and configured correctly and maximize the probability of success of your experiment.

IMPORTANT: Before launching the float, you must arm the mission by issuing the !AR command:

!AR

ARVOR-DEEP will respond:

<AR ON>

Put the magnet on the float (ON/OFF position).

NOTE: Once the mission is armed, the next time you will attempt to communicate with the float upon magnet removal, you need to establish Bluetooth connection (see section 2.5.2) and press "ENTER" within 50 seconds after magnet removal in order to get the prompt].

2.4.2 Remove protective plugs and magnet

The pump system of the CTD sensor is sealed by 3 protective plugs. Remove these plugs from the sensor before launching.

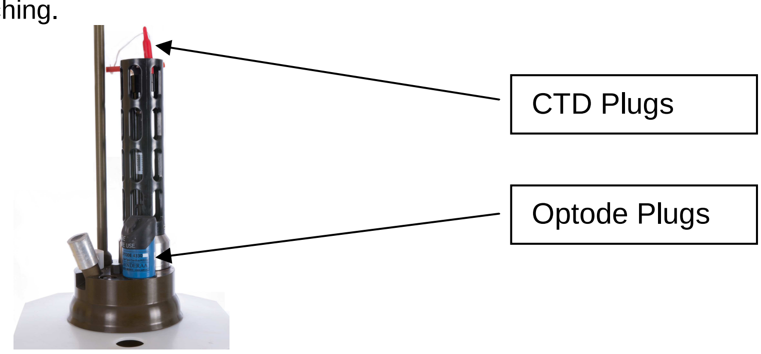


Figure 1 - Sensor plugs to remove

Remove the magnet located near the top of the float (seeFigure 2 - General view of ARVOR DEEP Float). Retain the magnet for future use in case the float is recovered.

ARVOR-DEEP is now ready for launch.

To confirm that the magnet has been removed and that the float is ready for launch, 5 seconds after magnet removal, ARVOR-DEEP starts 5 valves actions. After 80s, the seabird pump is active. If you have water in the CTD, this water go out by the holes where was the protectives plugs. After 100 sec, floats starts 5 quick valve activations.

NOTE: Once the magnet has been removed, the ARVOR-DEEP float performs an initial test. Ensure that the CTD pump starts as explained above before placing the float in the water.

If your do not hear the valve running after 30 seconds, and you do not see the water after 90s, replace the magnet, connect the PC, and conduct the tests described in section 2.5. If these tests fail, contact **nke instrumentation** technical support.

2.4.3 Deployment checklist

Test	Description	Expected Result	Result
Check before deployment			
1	Visual inspection	No scratch, good general state	☐ **OK**
2	Magnet Position	Magnet placed on ON/OFF position	☐ **OK**
3	Remove CTD & optode plugs (1 red & 2 white plugs, for CTD, black plug for optode)	Plugs removed (see section 2)	☐ **OK**
4	Distilled Water in conductivity cell	Introduce distilled water in conductivity cell (enable CTD pump check on test 8)	☐ **OK**
Check during deployment (Float must be on VERTICAL position)			
5	Magnet removal	Magnet removed from ON/OFF position	☐ **OK**
6	5 slow Ev activations	5 Ev activations heard (5-15 sec after magnet removal)	☐ **OK**
8	CTD pump	Water level change in CTD water circuit	☐ **OK**
9	One Minute Delay before mission begins	During 50 sec, user can connect to float with Bluetooth to enter in dialog mode. After this delay, floats begins mission (no more dialog possible with float, until new reset)	☐ **OK**
10	Auto-Test	Full auto-test (int. vacuum, batteries, sensors test, Iridium modem) Water level change in CTD water circuit	☐ **OK**
11	**5 Quick Ev activations**	**5 Ev activations heard**	☐ **OK**
12	Delay before mission	Wait for “Delay before bission” Minutes (“PM4” minutes)	☐ **OK**
13	Satellite Transmission	Iridium transmission (files received by mail SBD transmission	☐ **OK**
Deployment			
14	Deployment	Deployment system in place	☐ **OK**
15	Float drift	Float drift at surface	☐ **OK**

Table 1 - Deployment checklist

If **step 11** is not reached, place magnet on ON/OFF position and try again from beginning.

Do not DEPLOY after 3 unsuccessfull tries !

2.4.4 Launch the float

NOTE: Keep the float in its protective packaging for as long as possible to guard against any nicks and scratches that could occur during handling. Handle the float carefully, using soft, non-abrasive materials only. Do not lay the float on the deployment vessel's unprotected deck. Use cardboard or cloth to protect it.

2.4.4.1 By hand

ARVOR-DEEP can be launched by hand from the deck from a height of 2 meters

2.4.4.2 Using a rope

The damping disk is already fastened on the tube (under the buoyancy foam).

2.5 Checks prior to deployment

2.5.1 Necessary equipment

The equipment required to check that ARVOR-DEEP is functioning correctly and to prepare it for the mission are:

(1) A PC.
The most convenient way of communicating with ARVOR-DEEP is with a PC in terminal emulation mode. Among other advantages, this allows storage of configuration parameters and commands. You can use any standard desktop or laptop computer. The PC must be equipped with a serial port (usually called COM1 or COM2).

(2) VT52 or VT100 terminal emulation software.
The Hyper Terminal emulation software can be used.

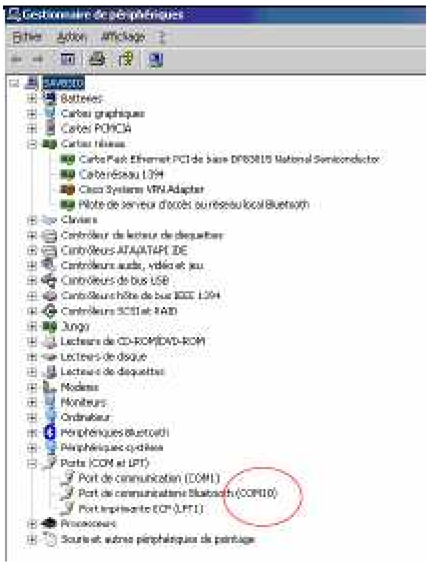
(3) A Bluetooth Dongle with drivers installed on the PC (BELKIN class 2 model is recommended).

(4) An accurate time source.
This could be a wristwatch, a GPS receiver or the PC's internal clock. Some users use a GPS receiver connected to the PC to adjust the clock.

2.5.2 Connecting the PC

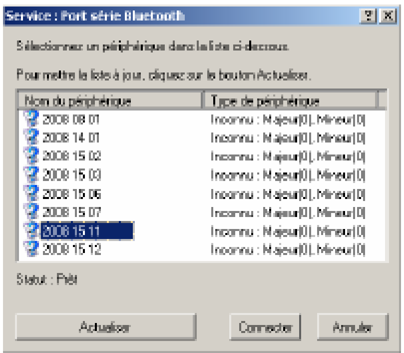
Make sure you check the following points before attempting a connection:

- ✓ Bluetooth key connected to the PC with the drivers installed
- ✓ Magnet present at the Bluetooth's power supply ILS (seeFigure 2 - General view of ARVOR DEEP Float)
- ✓ Start Hyperterminal after checking on which COM port the Bluetooth key is installed by going to: Control Panel->System-> click on Hardware tab->Device Manager as shown in the figure below:



- ✓ On the PC, run the following commands as shown in the figure below:
- ✓ Right click on the Bluetooth logo in the bottom right corner of the Desktop
- ✓ Select Quick Connect, Bluetooth Serial Port, then click on other devices

A window appears as shown in the figure below:



- ✓ Click on Refresh
- ✓ Check that the Bluetooth number is present on the traceability label (see Figure 2 - General view of ARVOR DEEP Float) There are two ways of establishing the connection:
- ✓ Either select the number shown and press Connect
- ✓ Or come back to the previous step and instead of selecting “other devices”, select the number shown
- ✓ When the connection is made, a dialog box appears as shown in the figure above:

Double click on it and a window appears as shown below:

- ✓ Enter the security code “0000”
- ✓ You can now check the connection by double clicking on the Bluetooth logo in bottom right corner of the Desktop

- ✓ The “Bluetooth favourites” window appears:

Use your PC's terminal emulation software to configure the selected serial port for:

- 9,600 baud
- 8 data bits
- 1 stop bit
- Parity: none
- Full duplex
- No flow control

2.5.3 Example of Bluetooth dongle tested by NKE

USB Bluetooth™ adaptor - 100 meters,
Part # F8T012fr
Made by Belkin

2.5.4 How to send commands

You must communicate with ARVOR-DEEP to verify or change its configuration parameters, to read data from the float, or to test the float's functions. You perform these verifications/changes by sending commands, and by observing the float's response to those commands. Compose commands by typing characters on the keyboard of your PC, and send them to ARVOR-DEEP by pressing the Enter key.
In the following descriptions of commands we will use the general syntax:

- Keystrokes entered by the user are written in **bold**.
- Replies received from the float are in normal font.
- Commands entered by the user end with the Enter key.

All command list is given in Section User Commands page 33

The software version can be viewed using the **?VL** command
ARVOR-DEEP will respond:
<VL 5608Y0x (where Y indicates Major software revision and x indicates minor software revision)
<VC IRIDIUM>
<AVEC OPTODE>

The float's serial number can be viewed using the **?NS** command
ARVOR-DEEP will respond:
<NS 14001> (year 14, identification 1)

2.5.5 How to Read and change Parameter Values

Read the values of "mission commands" by sending the PM command. Do this by typing the characters **?PM** in response to ARVOR-DEEP's] prompt character then confirm the command by pressing the Enter key. It should look like this:

?PM

ARVOR-DEEP will respond:

<PM0 255>
<PM1 10>
<PM2 2>
<PM3 6>
<PM4 0>
<PM5 0>
<PM6 12>
<PM7 10>
<PM8 1000>
<PM9 4000>
<PM10 10>
<PM11 200>
<PM12 1>
<PM13 10>
<PM14 25>
<PM15 60>
<PM16 0>
<PM17 1>

As you can see, the responses are of the form:

- PM parameter number, value.

You can also read the values of the parameters individually using the command : **?PM X**

where **X** identifies the parameter. Each parameter is identified by a parameter number corresponding to a parameter name. They are summarised for reference in **section 5.1** & **5.2**

Parameter no.	Name	Default Value	Units
Mission Parameters			
PM0	Number of Cycles	255	Whole number
PM1	Cycle Period	10	Nb of days
PM2	Reference Day	2	days
PM3	Estimated time at the surface	6	Hours
PM4	Delay Before Mission	0	Minutes
PM5	Descent Sampling Period	0	Seconds
PM6	Drift Sampling Period	12	Hours
PM7	Ascent Sampling Period	10	Seconds
PM8	Drift Depth	1000	dBar
PM9	Profile Depth	4000	dBar
PM10	Threshold surface/Intermediate Pressure	10	dBar
PM11	Threshold Intermediate /bottom Pressure	200	dBar
PM12	Thickness of the surface slices	1	dBar
PM13	Thickness of the intermediate slices	10	dBar
PM14	Thickness of the Bottom slices	25	dBar
PM15	Iridium End Of Life transmission period	60	Minutes
PM16	2^{nd} Iridium session wait period	0	Minutes
PM17	Wait at surface after grounding	1	Minutes

Table 2 - Mission Parameters

For example, to verify the value of the ascent sampling period, send the command:
? PM 7
ARVOR-DEEP will respond:
<PM7   10>
where 10 is the sampling period in ascent.
The commands for **changing** the values of the mission parameters are of the form:
!PM X Y
where X identifies the parameter and Y provides its new value.
For example, to change the number of cycles 200, send the command:
!PM 0 200
ARVOR-DEEP will respond:
<PM0   200>

NOTE: ***ARVOR-DEEP will always respond by confirming the present value of the parameter. This is true even if your attempt to change the parameter's value has been unsuccessful, so you should observe carefully how ARVOR-DEEP responds to your commands.***

2.5.6 How to check and change the time

Connect the PC to the float using the BT connection (see **section 2.5.2**). Ask ARVOR-DEEP to display the time stored in its internal clock by sending the command:
? TI
(Do this by typing the characters **? TI** followed by the Enter key). ARVOR-DEEP will respond:
<01/03/14, 14 41 00>
The date and time are in the format DD/MM/YY hh:mm:ss
You can set the time on the float's internal clock by sending the command:

!TI DD MM YY hh mm ss

For example, if you send the command:

!TI 01 03 14 14 30 00

ARVOR-DEEP will respond:

01/03/14, 14h 30m 00s

2.5.7 Configuration check

The float has been programmed at the factory. The objective of this portion of the acceptance test is to verify the float's configuration parameters.

Connect the PC to the float (see **section 2.5.2**). Send the PM command, as explained in **section 2.5.5.**, to verify that ARVOR-DEEP's parameters have been set correctly.

All command list is given in Section User Commands page 33

2.5.8 Functional tests

Connect the PC to the float (see **section 2.5.2**).

NOTE: The hydraulic components will function correctly only if the float is in a vertical position with the antenna up.

Orient the float vertically, and support it to prevent it from falling over during the performance of the functional tests.

2.5.8.1 Auto-test

Before sending float auto-test, place the float on vertical position.

These auto-test is used by float to check all internal components.

Standard auto-test can be done by sending command :

!C

Float will respond :

<CPU:OK VIDE :OK (600) BAT:OK (14400) CTD_PowerCtrl:OK CTD_FastPress:OK SENSOR_DO:OK IRIDIUM:OK FLASH:OK (3599)>

During auto-test, float will test “internal vacuum”, CTD sensor (CTD mode and pressure request), Oxygen sensor (optional), Iridium modem, parameters integrity and firmware integrity (checksum).

2.5.8.2 Display of technological parameters

This command is used to display :

- Internal vacuum (V).
  This vacuum is drawn on the float as one of the final steps of assembly. It should be between 500 and 700 mbar absolute. 600 mbar (@20°C) is recommended.

- Battery voltage (B)
  Normal values for a new battery are 14.4 volts (see test sheets for limits).
  Send the command :

?VB

ARVOR-DEEP will respond:

<B:145 V:605 (A=2.000 B=200.000)> meaning 14.5V for battery voltage and 605 mBars as internal vacuum

2.5.8.3 Display sensor data

This command is used to display:

- External pressure (P)
- Temperature (T)
- Salinity (S)

Send the command:

?S
ARVOR-DEEP will respond:
<S: 10cBars 24561mdc 12mPSU>
As this sensor is in open air, only the temperature data should be regarded as accurate.

2.5.8.4 Test of oxygen sensor

This command is used to perform an acquisition on the oxygen sensor.
Send the command :
?D
Provor will respond with :
<O2 : C1Ph : 56.850 ° C2Ph : 45.128 ° Temp : 17.128 °C >

2.5.8.5 Test hydraulic pump & valve

To activate the pump for one second, send the command :

!P 100
Listen for the pump running for one second (unit: centiseconds).

To activate the valve for one second, send the command:

!E 100
Listen for the actuation of the valve (unit: centiseconds).

2.5.8.6 Test Iridium/GPS subsystem

To test the Iridium transmitter, send the command :

!SE
The float will reprogram time with GPS, then will send a technical SBD message. Put the magnet back in place to stop the transmission.

This command will cause ARVOR-DEEP to transmit one technical message. The format of which is described in **section 6**. Use your email address to check transmission was OK. The message content is not meaningful, this is a test of the transmission only.

2.5.8.7 Test armed mode

To check if armed mode is ON or OFF, send the command :
?AR
Float will respond :
<AR ON> if armed mode is ON or <AR OFF> if armed mode is OFF.
Armed mode set “ON” means that float is ready for deployment. Armed mode set to OFF means that float enters in “user-dialog mode” each time float is powered ON.

You have now completed the functional tests. Ensure the magnet is in place on the ON/OFF position (see Figure 3 - Magnet positions).

<u>Before deployment, armed mode must absolutely be setted to ON !</u>

If armed mode is ON, next time float is powered ON, after a delay of 50 seconds, float begin a new mission and it won’t be possible to send command to float anymore. During the 50s delay, user can enter in “dialog mode” by connecting on bluetooth and type on “ENTER” until float send prompt character (**“]”**).

Armed mode is set in factory on request. This information (AR state) can also be verify by reading FIT file delivered with float.

You have now completed the functional tests. Ensure the magnet is in place on the ON/OFF position (see Figure 3 - Magnet positions).

3 GENERAL DESCRIPTION OF ARVOR-DEEP FLOAT

3.1 ARVOR-DEEP

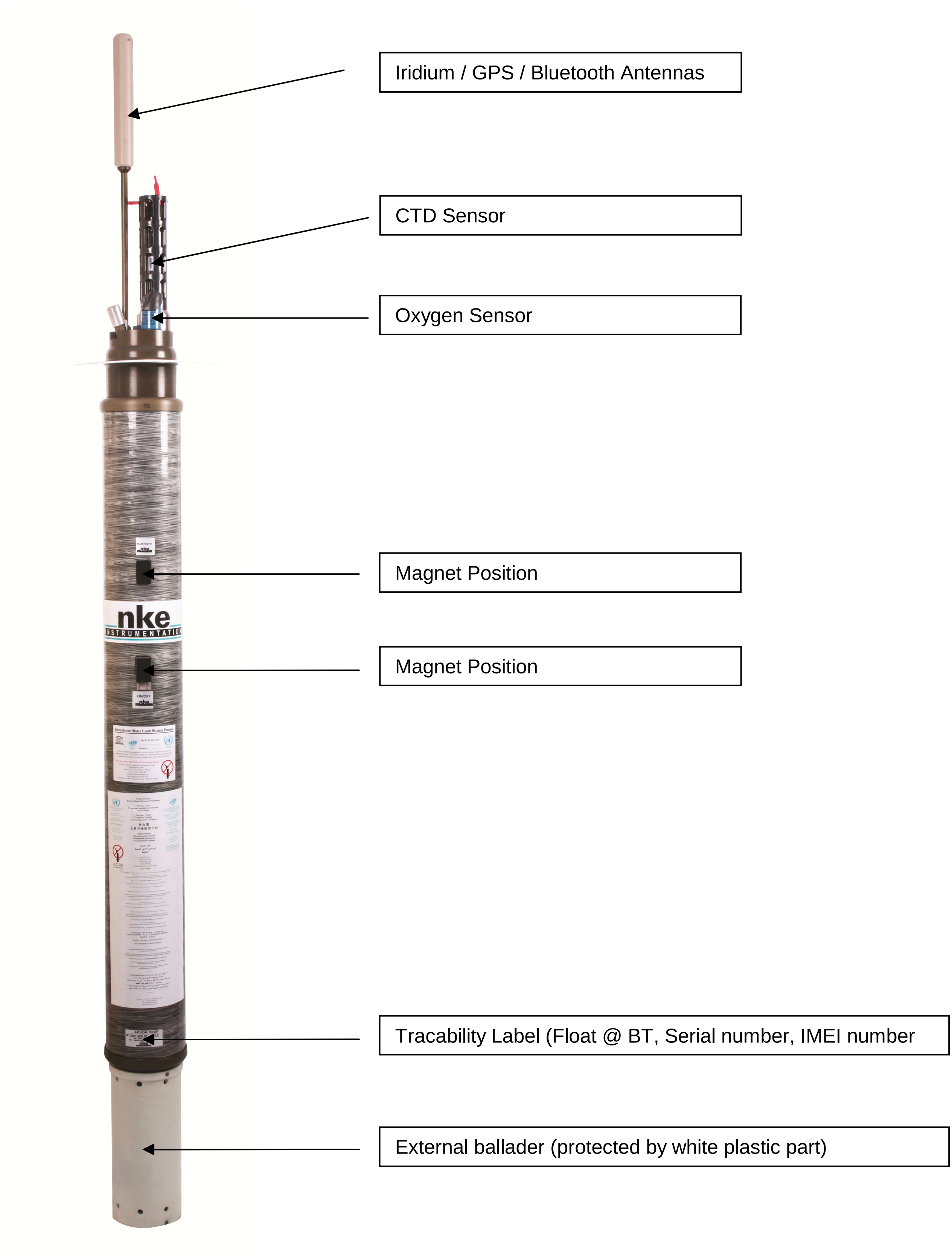


Figure 2 - General view of ARVOR DEEP Float

3.2 Hull

The ARVOR-DEEP float is encased in a cylinder measuring 11.3 cm in diameter and 100 cm in height. A surface finish prolongs life by impeding corrosion. The float is carefully designed to have a compressibility that is lower than that of seawater, essential for stable operation at ocean depths where pressures reach 410 atmospheres.

3.3 Magnet Positions

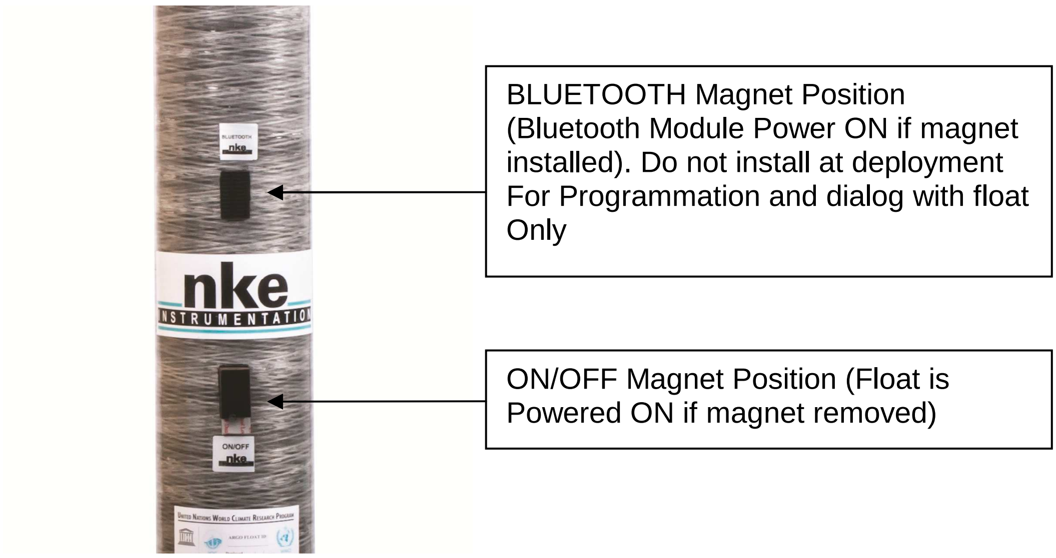


Figure 3 - Magnet positions

3.4 Density control system

Descent and ascent depend upon buoyancy. ARVOR-DEEP is balanced when its density is equal to that of the level of surrounding water. The float has a fixed mass. A precision hydraulic system is used to adjust its volume. This system inflates or deflates an external bladder by exchanging oil with an internal reservoir. This exchange is performed by a hydraulic system comprising a high-pressure pump and a solenoid valve.

The interested reader is referred to a more detailed description of the operation of ARVOR-DEEP's density control system in **section 8.**

3.5 Sensors

ARVOR-DEEP is equipped with precision instruments for measuring :

- pressure, temperature and salinity with the SEABIRD SBE41CP CTD sensor. Specifications of the sensor are provided in **sections 7.**

  Optional sensors :

- Dissolved Oxygen with the Oxygen Optode AANDERAA 3830 or 4330 sensor

3.6 Iridium/GPS modem

While the float is at the surface, the Iridium Modem sends stored data to the satellites of the Iridium system (see **sections 6. and 6.1.**). The transmitter has a unique IMEI ID. This ID identifies the individual float. The antenna is mounted on the top end of the ARVOR-DEEP float and must be above the sea surface in order for transmissions to reach the satellites.

3.7 CPU board

This board contains a micro-controller (or CPU) that controls ARVOR-DEEP. Its functions include maintenance of the calendar and internal clock, supervision of the depth cycling process, data processing and activation and control of the hydraulics.

This board allows communication with the outside world for the purpose of testing and programming.

3.8 Battery

A battery of lithium thionyl chloride cells supplies the energy required to operate ARVOR-DEEP.

3.9 MMI link

The User link is made via Bluetooth (radiofrequency link)

3.10 Firmware evolution in 2016

ARVOR-I firmware has been modified in 2015 with several objectives. Main objectives were :

- “Near surface” and “In air” measurement phases were added at the end of ascent phase. This is specifically useful for float equipped with optional dissolved oxygen sensor (optode), for saturation control in order to compensate potential sensor drift

4 THE LIFE OF AN ARVOR-DEEP FLOAT

The life of an ARVOR-DEEP float is divided into 4 phases: Storage/Transport, Deployment, Mission & Life Expiry.

(1) Storage/Transport
During this phase, the float, packed in its transport case, awaits deployment. The electronic components are dormant, and float's buoyancy control functions are completely shut down. This is the appropriate status for both transport and storage.

(2) Deployment
The float is removed from its protective packaging, configured, tested and launched at sea.

(3) Mission
The mission begins with the launching of the float. During the mission, ARVOR-DEEP conducts a pre-programmed number of cycles of descent, submerged drift, ascent and data transmission. During these cycles it collects CTD data, computes data, and transmits it to the Iridium satellite system.

(4) Life Expiry
Life Expiry begins automatically upon completion of the pre-programmed number of cycles. During Life Expiry, the float, drifting on the sea surface, periodically transmits messages until the battery is depleted. Reception of these messages makes it possible to locate the float, to follow its movements and, if desired, to recover it.

If the battery is depleted before completion of the pre-programmed number of cycles, ARVOR-DEEP will probably remain submerged and cannot be located or recovered.

4.1 The mission - overview

We call "mission" the period between the moment when the float is launched at the experiment zone and the moment when the data transmission relating to the final depth cycle is completed.

During the mission, ARVOR-DEEP conducts ascent and descent profiles, separated by periods of Iridium transmitting and drifting at a predetermined depth. ARVOR-DEEP can collect data during the descent, submerged drift, or ascent portions of the cycle, and transmits the collected data during the surface drift period at the end of each cycle. One cycle is shown in the figure below.

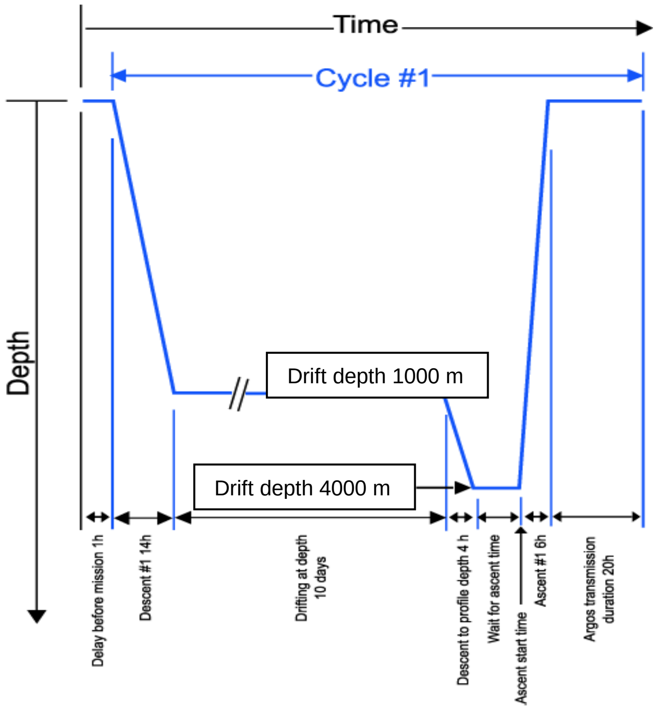


Figure 4 Schematic representation of a ARVOR-DEEP's depth-cycle during the Mission

(1) Delay before mission
To prevent ARVOR-DEEP from trying to sink before it is in the water, the float waits for this time before starting its descent. This happens only before the first cycle; it is not repeated at each cycle.

(2) IRIDIUM/GPS preliminary transmissions
To test Iridium transmitter, before descent phase, float will perform Iridium transmission by sending a technical message. A GPS position will be acquire and transmit in technical message.

(3) "Pressure sensor offset" reset
Resetoffset command is send to SBE41-CP sensor -> Sample pressure for 1 minute. Store measured pressure as new pressure offset. Maximum allowed offset is 2 percent of full scale.

(4) Buoyancy reduction
Float is deployed with full external bladder to get a maximal buoyancy. To reach neutral buoyancy position before descending, float needs to transfer oil inside float. For the 2 first cycles this phase can take up to one hour and a half (by opening electro-valve several times with one minute for pressure monitoring between activations). At following cycles, float memorized necessary global electro-valve opening time (precedent cycle) and reduce this global duration by reduce time between valve activations to 1 second instead of 1 min.

(5) Descent
The float descends at an average speed of 3 cm/sec. During descent, which typically lasts a few hours, ARVOR-DEEP can detect possible grounding on a high portion of the seabed and can move away from such places (see **section 4.3.** for more details on grounding). ARVOR-DEEP can collect CTD measurements during descent or ascent. In order to respect the requirement of the ARGO program, the first cycle of the mission collect CTD measurements during the descent at the sampling period of 10 seconds.

(6) Drifting at parking depth
During the drift period, ARVOR-DEEP drifts underwater at a user-selected drift depth, typically 1,000m to 2,000m below the sea surface. The drift period is user-selectable and can last from a few days to several weeks, but is typically 10 days. The float automatically adjusts its buoyancy if it drifts from the selected depth by more than 5 bars over a 60-minute period. ARVOR-DEEP can collect CTD measurements at user-selected intervals during this drift period if the user selects this option.

(7) Descent to profile depth
The user may select a starting depth for the ascent profile that is deeper than the drift depth. If this is the case, ARVOR-DEEP must first descend to the profile depth before beginning the ascent profile. ARVOR-DEEP can detect a possible grounding during this descent and take corrective action (as described in **section 4.3.)**

(8) Wait for ascent time

The user can program several floats to conduct profiles simultaneously. This makes it possible to use several ARVOR-DEEP floats in a network of synoptic measurements, even though the instruments are not all deployed at the same time. If this is the case, it may be necessary for ARVOR-DEEP to standby at the profile starting depth while awaiting the scheduled ascent time.

(9) Ascent

Ascent lasts a few hours, during which time ARVOR-DEEP ascends to the sea surface at an average speed of 10cm/sec. ARVOR-DEEP can collect CTD measurements during descent or ascent.

(10) "Near surface" and "In Air" Measurement

Floats realizes specific acquisition for CTD and Dissolved Oxygen (option) near surface and also after float reaches maximum buoyancy.

(11) Transmission

At the end of each cycle, the float finds sufficient buoyancy to ensure Iridium transmission quality. ARVOR-DEEP remains at the sea surface transmitting the data collected during the preceding descent-drift- ascent portion of the cycle.

4.2 Descent

While the float is still at the sea surface ARVOR-DEEP measures and records its pressure sensor offset. This offset is used to correct all pressure measurements. The offset is transmitted in a technical message (see **section 6.)** for a description of technical messages format). Descent takes the float from the sea surface to the drift depth. Initially, in order to avoid possible collisions with ships, ARVOR-DEEP's objective is to lose buoyancy in the shortest possible time. It does this by opening the solenoid valve for a time period that is initially long, but decreases as the float approaches its target depth.

If the user chooses, ARVOR-DEEP will collect CTD measurements during descent and/or during ascent. The interval between CTD measurements is user-programmable.

4.3 Grounding

ARVOR-DEEP monitors itself for possible grounding on the seabed. During descent to drift depth, if the pressure remains unchanged for too long, ARVOR-DEEP enters a correction mode. The user selects one of two available modes during mission programming before launch (Technical parameter PT 10) :

- Grounding Mode = 0: The pre-programmed drift depth is disregarded. The pressure at the time of grounding minus an offset (100 dBar typical) is taken as the new value for the drift pressure. The float adjusts its buoyancy to reach this new drift depth. The drift depth reverts to its programmed value for subsequent cycles. If the grounded pressure is lower than a programmed threshold (200 dBar), the float remains on the seabed until the next programmed ascent time.
- Grounding Mode = 1: the float remains where it is until the next scheduled ascent time. The pressure measured at grounding becomes the profile start pressure for the cycle in progress. The profile start pressure reverts to its programmed value for subsequent cycles.

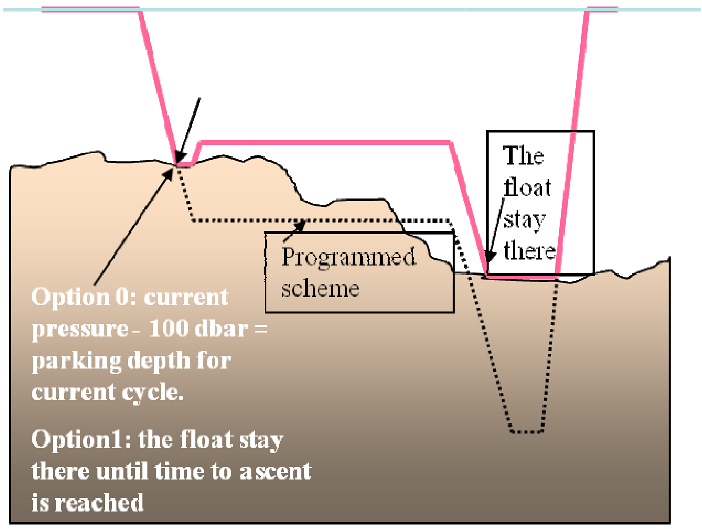


Figure 5 - Schematic representation of a ARVOR-DEEP's behaviour in case of grounding

4.4 Submerged drift

While ARVOR-DEEP is drifting at drift depth, it checks the external pressure every 30 minutes to determine whether there is need either for depth adjustment or for an emergency ascent.

If the measured pressure differs from the drift depth pressure by more than a specified tolerance, and this difference is maintained, ARVOR-DEEP adjusts its buoyancy to return to the drift depth.

If the pressure increases by an amount that exceeds a factory-set danger threshold, ARVOR-DEEP immediately ascends to the sea surface.

If the user chooses, ARVOR-DEEP will collect CTD measurements at user-selected intervals (every PM 6 hours) during submerged drift.

4.5 Ascent

If the chosen ascent profile starting pressure (PM9) is higher than the drift pressure (PM8) , the float must first descend to reach the profile starting pressure.

If grounding is detected while ARVOR-DEEP is descending to the profile starting pressure, the present pressure is substituted for the profile starting pressure. This substitution is only for the cycle in progress; the profile starting pressure reverts to its pre-programmed value for subsequent cycles.

Once the profile starting pressure has been reached, the float waits for the programmed time to begin the ascent. If this time is reached before the float has arrived at the profile starting pressure, the ascent starts immediately.

ARVOR-DEEP ascends by repeated use of the pump. When the pressure change between two successive measurements is less than 1 bar, the pump is activated for a pre-set time period. In this way, the pump performs minimum work at high pressure, which ensures minimum electrical energy consumption. The average speed of ascent is approximately 10cm/sec. For a 4,000m profile, the ascent would therefore last 12 hours.

When the pressure drops below 10 dBar (signifying completion of ascent), ARVOR-DEEP waits 10 minutes and then activates the pump in order to empty the reservoir and achieve maximum buoyancy. If the user chooses, ARVOR-DEEP will collect CTD measurements during descent and/or ascent. CTD measurements begin at the profile start time and stop 10 minutes after the float rises above the 10 dBar isobar in its approach to the sea surface. The interval between CTD measurements is user-programmable. For example, during a profile beginning at 4,000 m with a 10 sec sampling period, 4300 CTD measurements will be collected.

4.5.1 Ice detection (with firmware 5608A13 and higher)

At the end of ascent, if ice detection option is activated, float starts ice detection in order to stop ascent and avoid hit ice with risk to remain blocked under ice.

To detect ice, float uses 3 mechanisms :

- ISA method (Ice Sensing Algorithm), used for Antarctic area
- Satellite visibility
- Pressure evolution

If ice is detected, float stops ascent and aborts “In Air “ measurement and satellite transmission. In that case, SBD packets are created and stored into float internal memory to be transmitted next time float will really reach surface.

4.5.1.1 ISA detection

Between 2 thresholds (PG3 & PG4); float computes median temperature. If temperature is inferior to PG5 (default : -1.79°C), float decides ice detection as positive. From threshold PG6, float decreases speed from approx. 9 cm/sec to approx. 3.33 cm/sec (default values), to acquire necessary raw CTD data to compute median temperature.

4.5.1.2 Satellite visibility

A 2nd mechanism enables to detect ice, based on GPS end Iridium satellite visibility.

4.5.1.3 Pressure evolution

A 3rd mechanism is based on pressure evolution during ascent phase. If during PG12 minutes, despite pump actions, pressure evolution is inferior to minimum value, float decides ice detection as positive. We call blocking in ascent phase.

Once ice detection is positive, float activates valve to transfer oil (volume given by PG14 parameter), until pressure has increased of PG13 dBar. In the same time, float creates SBD packets for past cycle, and stores all packets in non-volatile memory. Float can store up to 2400 SBD packets (of all types). These packets will be transmitted during next transmission session. More ancient packets will be erased by new ones, in case, float remains for long time under water without emergence & transmission.

4.5.1.4 Ice detection principle schematics

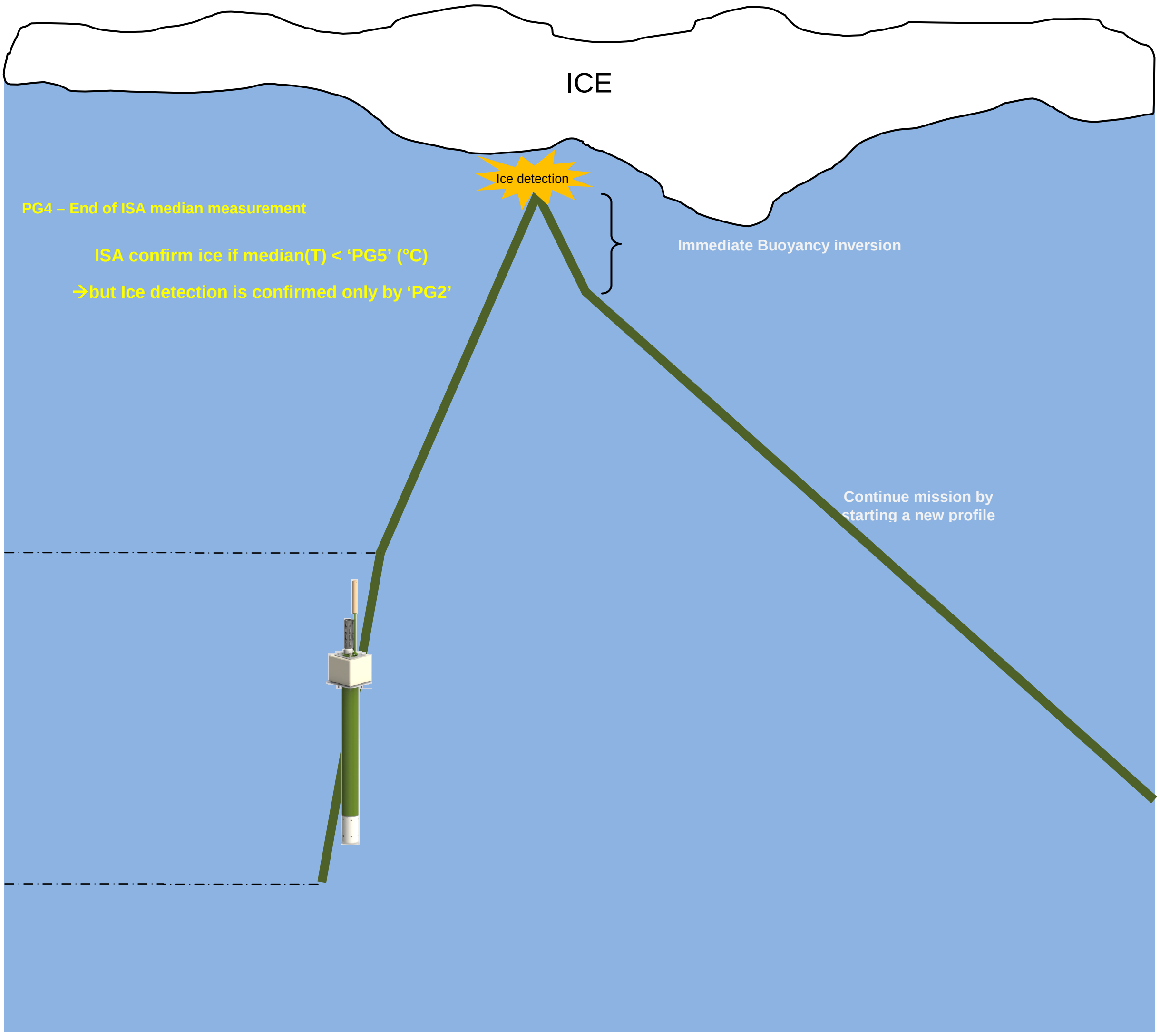


Figure 6 – Ice detection mechanisms

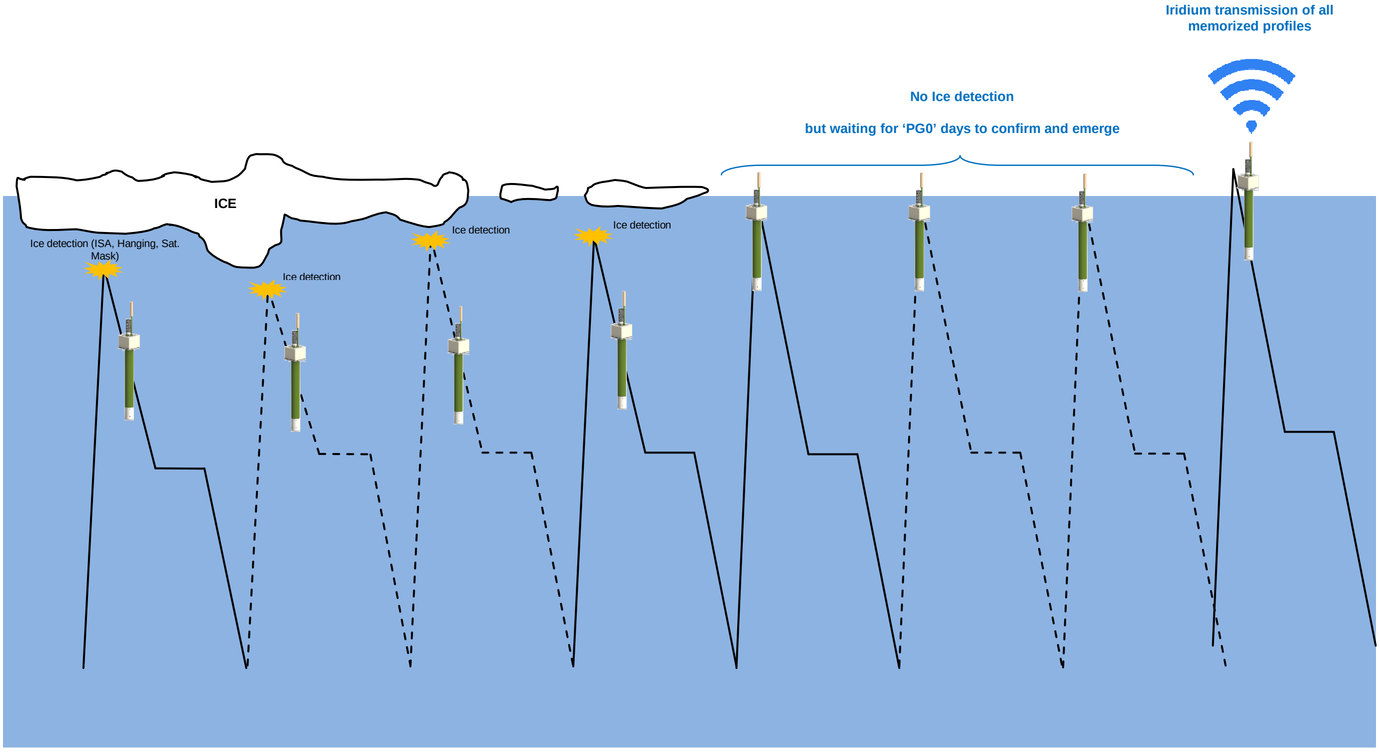


Figure 7 – Transmission after ice detection principle

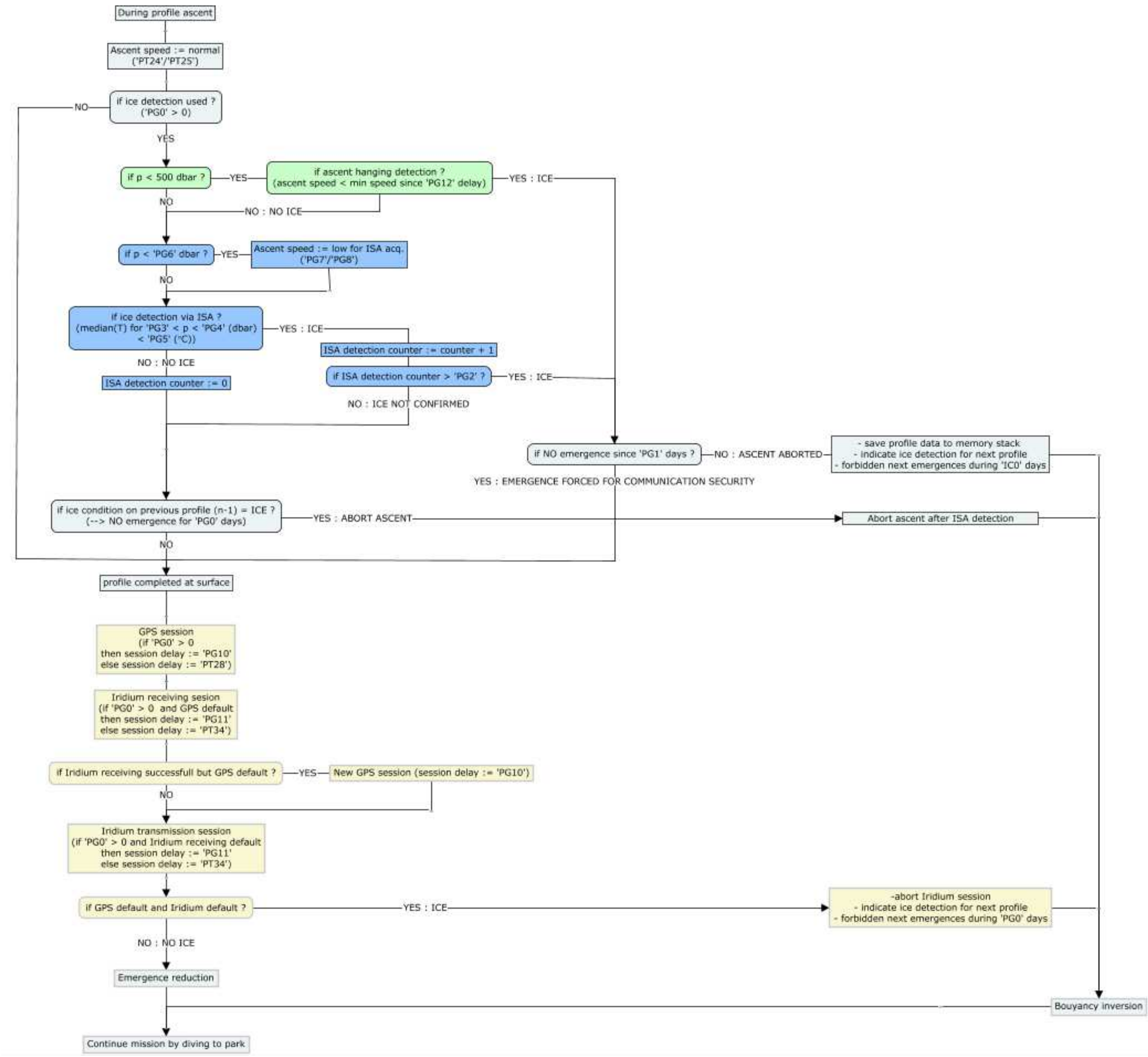


Figure 8 –Ice detection Synoptic

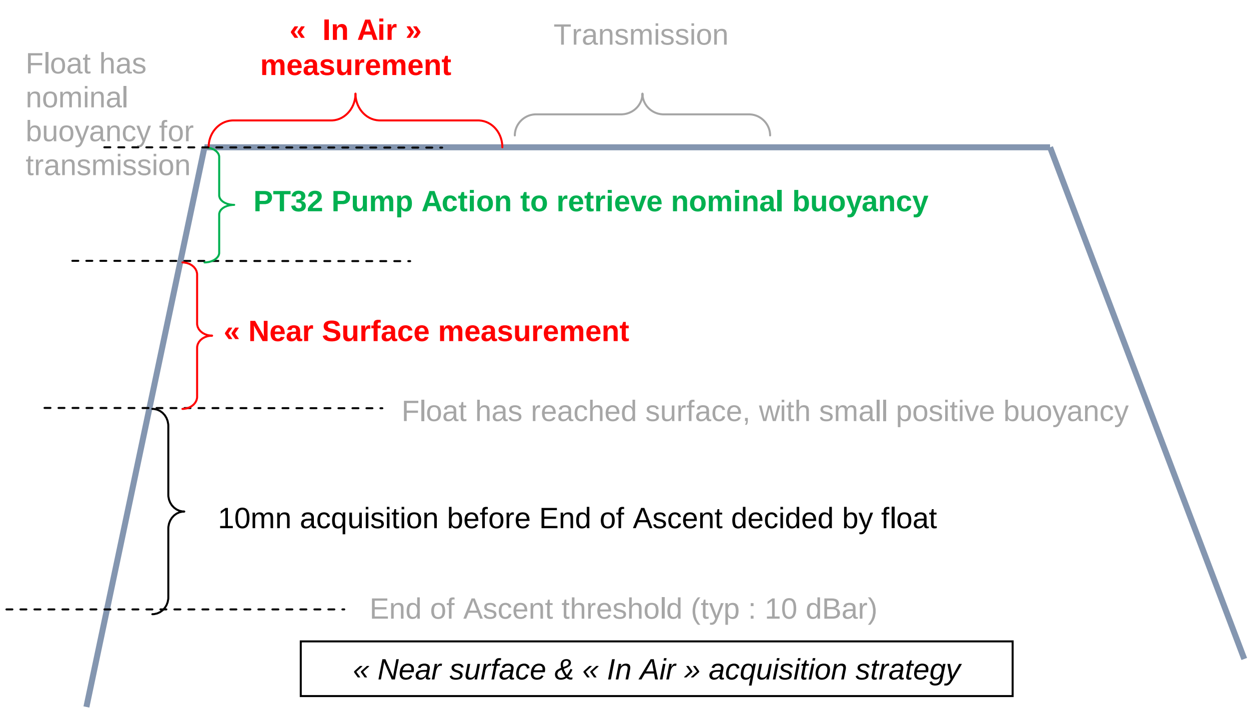
4.6 "Near surface" and "In Air" measurement

User can choose to set-up this kind of measurement or not. "In Air" measurement enables dissolved oxygen verification once float reaches surface. A few measurement are done as float is "Near surface" and also after float retrieve maximal buoyancy (after final pump action : "In Air"). Three parameters are used to set-up measurements : PT30, PT31, PT32 & PT33. PT33 set up measurement periodicity. PT33 = 1, means "In Air" measurement at each cycle. PT33=0 means no "In Air" measurement. PT33 = x, means "In Air" measurement every "x" cycles.

PT30 set-up interval between each "In Air" sample, and PT31 set-up duration for "In Air acquisition.

PT32 set-up duration of pump action as float arrives at surface (replaces PT4 for cycle without "In air" acquisition

Float realizes 1st, acquisition just before pump action (= Near Surface) that give float nominal buoyancy at surface. Then float realizes a 2nd phase of "in Air" Measurement. Both samples are transmitted in SBD packets.



« Near surface & « In Air » acquisition strategy

4.7 Transmission

The data transmission process takes into account the limitations of the Iridium data collection system, including:

- the uncertainty of the float's antenna emerging in rough seas;
- radio propagation uncertainties due to weather conditions, and;
- the satellites' operational status.

ARVOR-DEEP creates transmission messages from the stored "Treated data" (see **section 6.14**. for treatment details). The transmission of all messages is repeated until the total duration of transmissions exceeds the user-programmed minimum duration. The interval between transmissions is also user-programmable.

Please refer to **section 6.** for a detailed description of the transmitted message formats.

5 ARVOR-DEEP PARAMETERS

ARVOR-DEEP's configuration is determined by the values of its mission parameters defined below. Instructions on how to read and change the values of these parameters are provided in **sections 2.5.5.** The following table summarizes all parameter names, ranges and default values (Software YLA5608Y0x).

Parameter no.	Name	Default Value	Units
Mission parameters			
PM0	Number of Cycles	150	Whole number
PM1	Cycle Period	10	Days
PM2	Reference Day	2	Float day
PM3	Estimated time at the surface	6	Hours
PM4	Delay Before Mission	0	Minutes
PM5	Descent Sampling Period	0	Seconds
PM6	Drift Sampling Period	12	Hours
PM7	Ascent Sampling Period	10	Seconds
PM8	Drift Depth	1000	dbars
PM9	Profile Depth	4000	dbars
PM10	Threshold surface/Intermediate Pressure	10	dbars
PM11	Threshold Intermediate /bottom Pressure	200	dbars
PM12	Thickness of the surface slices	1	dbars
PM13	Thickness of the intermediate slices	10	dbars
PM14	Thickness of the Bottom slices	25	dbars
PM15	Iridium End Of Life transmission period	60	Minutes
PM16	Iridium 2^{nd} session waiting time (“0” means no 2^{nd} session)	0	Minutes
PM17	Wait at surface after grounding	1	Minutes

Table 3 - Summary of ARVOR-DEEP user-programmable parameters

5.1 Mission Parameters

PM(0) Total number of cycles of the mission

This is the total number of cycles of descent, submerged drift, ascent and transmission that ARVOR-DEEP will perform. After the completion of “PM0” cycle, the mission ends and ARVOR-DEEP enters in Life Expiry mode.

The capacity of ARVOR-DEEP's batteries is sufficient for at least 150 cycles. If you wish to recover ARVOR-DEEP at the end of its mission, you must set a number of cycles at less than 150 to ensure there is sufficient battery capacity remaining to allow ARVOR-DEEP to return to the sea surface and enter Life expiry mode.

Under favourable conditions, the battery capacity may exceed 150 cycles. If you do not plan to recover the ARVOR-DEEP float, you may choose to set the number of cycles over 150 to ensure that ARVOR-DEEP completes the maximum number of cycles possible.

PM(1) Cycle period (days)

The duration of each cycle of descent, submerged drift, ascent and transmission. ARVOR-DEEP waits submerged at the drift depth for as long as necessary to make the cycle the selected duration.

PM(2) Reference Day (float internal day number)

The float’s internal clock day number is set to zero when the mission starts. When this float day number equals the reference day “PM2”, the float performs its first profile.

Thus, as this parameter defines a particular day on which the first profile is to be made, it allows you to configure a group of floats so that they all conduct their first profile at the same time.

When setting the reference day, it is recommended to allow enough time between the deployment and reach of profiling depth. Using a reference day of at least 2 will ensure the first profile to be completed.

PM(3) Expected time at the surface (hours)
Expected time (hour in the day) the float must reach the surface.

PM(4) Delay before mission (minutes)
To prevent ARVOR-DEEP from trying to sink while still on deck, the float waits for this time before commanding the buoyancy engine to start the descent. After disconnection of the PC, followed by removal of the magnet, ARVOR-DEEP will wait for this delay before beginning the descent. The delay is measured after the first start of the pump which confirms the removal of the magnet (see **section 2.4.1**) and before the start of the descent.

PM(5) Descent sampling period (seconds)
The time interval between successive CTD(O) measurements during descent.
If this parameter is set to 0 seconds, no profile will be carried out during the descent phase. Nevertheless, due to the ARGO requirements, the first descent profile of the mission is automatically done even if the parameter was equal to 0.

PM(6) Drift sampling period (hours)
The time interval between successive CTD measurements during ARVOR-DEEP's drift at parking depth.

PM(7) Ascent sampling period (seconds)
The time interval between successive CTD measurements during ascent.
If this parameter is set to 0 seconds, no profile will be carried out during the ascent phase. Minimum value should not be set inferior to 10 sec.

PM(8) Drift depth (dbar) **
The depth at which ARVOR-DEEP drifts after completion of a descent while awaiting the time scheduled for the beginning of the next ascent.

PM(9) Profile Depth **
Depth at which profiling begins if in an ascending profile. If ARVOR-DEEP is drifting at some shallower depth, it will first descend to the profile depth before starting the ascent profile.

PM(10) Threshold surface/intermediate pressure (dbar) **
The isobar that divides surface depths from intermediate depths for the purpose of data reduction.

PM(11) Threshold Intermediate / bottom pressure (dbar) **
The isobar that divides Intermediate depths from deep depths for the purpose of data reduction.

PM(12) Thickness of the surface slices (dbar) **
Thickness of the slices for shallow depths (algorithm of data reduction).

PM(13) Thickness of the intermediate slices (dbar) **
Thickness of the slices for intermediate depths (algorithm of data reduction).

PM(14) Thickness of the bottom slices (dbar) **
Thickness of the slices for deep depths (algorithm of data reduction).

PM(15) Iridium End of life transmission period (minutes)
Transmission period (in hours) once float is in "end of life mode" (all programmed cycles have been reached. Float send Technical SBD message.

PM(16) 2nd Iridium session wait period (minutes)
At beginning of cycle, if this parameter is different of zero, 2 SBD sessions will occur. This enable to check if a change on mission or technical parameter has been correctly treated by float and if new parameters are effective for next cycle. After the 1st transmission, float will wait for PM16 minutes before proceeding to 2nd transmission.

PM(17) Delay in case of grounding at surface (minutes)

Period (in minutes) float will wait at the surface in case of grounding at the surface during Buoyancy reduction, before trying again to sink.

****** ARVOR-DEEP can transmit up to 1000 (4000 with firmware 5608A13 & higher) samples per cycle. Theoretical number of samples to be acquired can be estimated based on vertical zones and slices thicknesses.

5.2 Ice detection commands (firmware 5608A13 & higher)

	Command no.	Name	Default Value	Units
	Ice detection commands			
	PG0	Number of days without surface emergence if ice detected	10	1 day
	PG1	Number of days before surface emergence even with ice detected	90	1 day
ISA	PG2	Number of detections to confirm ice at surface	3	1 detection
	PG3	Start pressure detection	40	1 dBar
	PG4	Stop pressure detection	10	1 dBar
	PG5	Temperature threshold	-1600	0.001°C
	PG6	Slowdown pressure threshold	150	1 dBar
	PG7	Pressure acquisition period during ascent (slow speed), once P < IC6	2	1 minute
	PG8	Pressure delta min before pump action	2	1 dBar
	PG9	Pump action duration	500	0.01 second
Satellite criteria	PG10	GPS timeout	5	1 minute
	PG11	1st Iridium lock timeout	10	1 minute
Ascent blocking	PG12	Delay before ascent blocking detection	90	1 minute
Buoyancy inversion	PG13	Pressure variation for buoyancy inversion	20	1 dBar
	PG14	Volume of valve action volume for buoyancy inversion	9	1 cm3
	PG15	Max volume before grounding detection (while in buoyancy inversion phase)	900	1 cm3

PG(0) Number of days without ascent if ice detected
This is the total number of days for float (after ice detection is confirmed, so after PG2 ISA detection), to disallow emergence.

PG(1) Number of days before ascent even with ice detected
This is the maximum number of days for float before transmission, even if ice is detected during ascent on several cycles This mechanism enables float to emerge and try to transmit in order not staying drifting for infinite period.

PG(2) Number of detection to confirm ice at surface
This is the number of ice detection with ISA algorithm to confirm ice at surface. This is used to prevent from false detection.

PG(3) Start pressure detection (dBar)
This is the pressure for float to start ISA algorithm for ice detection.

PG(4) Stop pressure detection (dBar)
This is the pressure for float to stop ISA algorithm for ice detection.

PG(5) Temperature threshold (0.001° C)
Temperature threshold for ice detection with ISA algorithm. If Temperature is inferior to PG5 value, ice detection is positive.

PG(6) Slowdown pressure threshold (dBar) *
This is the pressure threshold for float to decrease ascent speed to prepare for ISA detection method.

PG(7) Pressure acquisition period during ascent (slow speed), once P < PG6 (dBar) *
The time interval for minimum pressure variation (PG8 dBar) verification. If (with default values),real pressure variation is inferior to PG8 during PG7 minutes, float activates hydraulic pump (4 dBar / 2 Minutes = 2 dBar/min or 3.33 cm/sec).

PG(8) Pressure delta min before pump action (dBar) *
This is the minimum pressure variation (during PG7 minutes), before float activates pump (duration : PG9).

PG(9) Pump action duration (0.01 second) *
This is the pump action duration, once pressure is inferior to PG6 value (if ice detection is requested). Replace PT3 in ISA area (from PG3 to PG4 dBar).

PG(10) GPS timeout (Minute) *
This is maximum time for GPS to acquire good fix, in case ice detection is requested.

PG(11) 1st Iridium lock timetout (Minute) *
This is maximum time for Iridium modem to acquire good fix, in case ice detection is requested. Once fix is done, for transmission, timeout becomes PT34 (as transmission has started, surface is free of ice, so float uses standard Timeout).

PG(12) Delay before ascent blocking detection (Minute) *
This is the delay for float to detect ascent blocking.

PG(13) Pressure variation for speed inversion(dBar) *
This is the pressure delta to detect that float has finished buoyancy inversion.

PG(14) Valve action volume (cm3) *
This is the unit volume of each valve action during buoyancy inversion phase.

PG(15) Max valve volume to detect grounding on descent *
This is the maximum volume for valve action during buoyancy inversion

*: all these parameters requires good expertise and float technical knowledge for modification. It is recommended to contact nke instrumentation for modification.

5.3 Technical Parameters

Technical parameters 0 to 29 must be modified by expert user only and for specific application. Please contact nke for more detail.

Technical parameters 30 to 33 are used to set-up “Near surface” & “In air” acquisition.

Parameter	Name	Default Value	Units
Technical Parameters			
PT0 to PT 29	Contact nke for more detail		
PT30	In air acq.: Sampling period	**30**	Seconds (min:10s, max:300s)
PT31	In air acq.: Acquisition duration	**5**	Minutes (min:0mn, max:3600mn)
PT32	In air acq.: Duration of pumping at surface	**30000**	Centisec (min :20000, max :65000)
PT33	In air acq.: Periodicity of in air measurement	**0**	0=no acq. 1=acq. on each cycle X=acq. on 1/x profile (min:0, max:250)
PT34	Contact nke for more detail		
PT35	Contact nke for more detail		

PT(30) In air acq.: Sampling period
Delay between each CTD sample acquired during “Near surface “& “In Air acquisition” phase

PT(31) In air acq.: Acquisition duration
Total duration for “In Air” acquisition (same for Near surface acquisition)

PT(32) In air acq.: Duration of pumping at surface
Surface pump action duration once float arrived at surface to enables god transmission and also to place optode sensor in air condition.

PT(33) In air acq.: Periodicity of in air measurement
Cycle periodicity for “In Air acquisition to be executed.
0 means no “In Air acquisition
1 means “In Air acquisition” every cycle
X means “In Air acquisition” one cycle every “x” cycles

5.4 User commands

Command	Rôle
!C	Float auto-test.
?CK	Firmware checksum check
!SE	Initiate Iridium transmission session
!PM x y	Set value y for “Parameter mission” x
?PM	Screen all mission parameters
?PM x	Screen mission parameter x
!PT x y *	Set value y for “technical parameter” x
?PT *	Screen all technical parameters
?PT x *	Screen technical parameter x
!PG x y	Set value y for “ice command” x
?PG	Screen all ice commands
?PG x	Screen ice command x
!SH	Activate or de-activate Show mode **MUST BE OFF FOR DEPLOYMENT**
?SH	Request show mode state
!TI jj mm aa hh mn ss	Set date and time to dd/mm/yy hh H : mn M : ss S
?TI	Request float’s internal date and time
?DH	Read all hydraulic data (pump and electrovalve activations)
?DT ALL x	Read all Treated Data for sensor x
?DB	Read all Raw Data for sensor x
!E x	Activate electrovalve for x cs (ctrl-c to stop)
!P x	Activate pump for x cs (ctrl-c to stop)
?S	CTD sensor acquisition
?FP	Fast Pressure request
?VB	Request internal vacuum and battery voltage (in decivolt and milliBars)
!AR	Arm float or deactivate arm mode **MUST BE ON FOR DEPLOYMENT**
?AR	Request arm state
!RP	Parameters are transfered from EEPROM memory to RAM memory
?VL	Request software version
?NS	Request float’s serial number
!K x	Command to activate or deactivate read/Write access for technical parameters. X value is communicated to users upon request to nke
?RE	Read the 5 last reset date and time
!PB	Request Battery Voltage with hydraulic pump active

Table 4 - User command list

* : protected command (need !K x to unlock)

6 IRIDIUM FORMATS

6.1 Overview

The data transmission process begins as soon as an ascent profile is completed. It starts with reduction of the data. ARVOR-DEEP then formats and transmits the message. The reduction of data processing consists in storing the significant points of the CTD triplets arithmetic mean with the layer format.

SBD message contains up to 3 packets (300 bytes max). One packet have a 100 bytes size

message :

packet	packet	packet

Ten types of packets are generated according to the content of the data frame:

Packet type number	Message Type
0	Technical message n°1
1	Descent CTD message
2	Drift CTD message
3	Ascent CTD message
4	Technical message n°2
5	Programmation Message n°1
6	Hydraulic message
7	Programmation Message n°2
8	Descent CTDO message
9	Drift CTDO message
10	Ascent CTDO message
11	CTDO Near surface
12	CTDO In Air
13	CTD Near surface
14	CTD In Air

⇨

300 bytes message N°1 sent

300 bytes message N°2 sent

300 bytes message N°n sent

The three types of CTD messages and 3 types of CTDO messages all contain recorded physical measurements. The technical messages contains data regarding the configuration and functioning of the float and its buoyancy control mechanism.

The message type is formed from the first byte of the data frame. The formatting of the data frame for each message type is described in the following pages.

6.2 Technical message 1 (type =0)

	Data	Format (bytes)	Resolution
0	Type (= 0)	1	
	General informations		
1	Cycle number	2	
	Buoyancy reduction		
2	Day of beginning	1	1 day
3	Month of beginning	1	1 month
4	Year of beginning	1	1 year
5	Relative start day (to mission's beginning)	2	
6	Cycle start time	2	1 min
7	Hydraulic action	2	1 action
8	number of valve actions at the surface	1	1 action
9	Grounded at surface	1	0 = no, 1 = yes
	Parking depth descent		
10	Descent (to parking depth) start time	2	1 min
11	Float first stabilisation time	2	1 min
12	Descent (to parking depth) end time	2	1 min
13	Number of valve actions during descent to parking depth	1	1 action
14	Number of pump actions during descent to parking depth	1	1 action
15	Float first stabilisation pressure	2	1 dBar
16	Max pressure during descent to parking depth	2	1 dBar
	Parking drift Phase		
17	Beginning drift phase Absolute day	1	1 day
18	Number of entrance in parking depth target range (descent)	1	
19	Number of repositions during drift at parking depth	1	
20	Minimum pressure during drift at parking depth	2	1 dBar
21	Maximum pressure during drift at parking depth	2	1 dBar
22	Number of valve actions during drift at parking depth	1	1 action
23	Number of pump actions during drift at parking depth	1	1 action
	Descent to profile depth		
24	Descent (to profile depth) start time	2	1 min
25	Descent (to profile depth) end time	2	1 min
26	Number of valve actions during descent tp profile depth	1	1 action
27	Number of pump actions during descent to profile depth	1	1 action
28	Max pressure during descent to profile depth	2	1 dBar
	Drift at Profile depth Phase		
29	Number of entrance in profile depth target range (descent)	1	
30	Number of re-positioning during drift at profile depth	1	
31	Number of valve actions during drift at profile depth	1	
32	Number of pump actions during drift at profile depth	1	
33	Minimum pressure during drift at profile depth	2	1 dBar
34	maximum pressure during drift at profile depth	2	1 dBar

	Ascent phase		
35	Profile ascent start time	2	1 min
36	Transmission start time	2	1 min
37	Number of pump actions in ascent	1	1 action
	General information		
38	Float's time (hh+mm+ss)	3	1h, 1min, 1sec (1 byte each)
39	Float's date (dd+mm+yy)	3	1day, 1month, 1year, 1byte each
40	Pressure sensor offset (two's complement coded)	1	1 cBar
41	Internal pressure	1	5 mBar
42	Bbatteries voltage drop at Pmax, pump ON (with regard to Unom = 15.0 V) (in dV)	1	0.1 V
43	RTC state indicator (normal = 0, failure = 1)	1	
44	Coherence problem counter	1	
45	Oxygen sensor Status (0 = normal, 1 = failure)	1	
	GPS Data		
46	GPS latitude in degrees	1	1 degree
47	GPS latitude in minutes	1	1 minute
48	GPS latitude in minutes fractions (4^{th})	2	1 minute fraction (4^{th})
49	GPS latitude orientation (0= North, 1 = South)	1	
50	GPS longitude in degrees	1	1 degree
51	GPS longitude in minutes	1	1 minute
52	GPS longitude in minutes fractions (4^{th})	2	1 minute fraction (4^{th})
53	GPS longitude orientation (0= East, 1 = West)	1	
54	GPS valid fix (1 = valid, 0 = not valid)	1	
55	GPS session duration	2	1 second
56	GPS retries	1	
	Iridium remote control		
57	Number of remote control received	1	
58	Number of remote control rejected	1	
	End Of Life information		
59	End Of Life detection flag	1	1 = End Of life
60	End Of life Start hour	3	1h, 1min, 1sec (1 byte each)
61	End Of life Start Date	3	1day, 1month, 1year, 1byte each
	Previous transmission information		
62	Previous Iridium transmission duration	2	1 sec
63	Number of SBD session for reception	1	
64	Number of SBD session for transmission	2	
65	Not used (filled by zeros)	4	
	Total	100	

Table 5 - Technical message n°1

6.3 Technical message 2 (type = 4)

	Data	Nb bytes	Res
0	Type (=4)	1	
	General informations		
1	Cycle number	2	
	Data Information		
2	Number of descent CTD messages	1	1 packet
3	Number of drift CTD messages	1	1 packet
4	Number of ascent CTD messages	1	1 packet
5	Number of descent slices in shallow zone	2	
6	Number of descent slices in deep zone	2	
7	Number of CTD measurements in drift	1	
8	Number of ascent slices in shallow zone	2	
9	Number of ascent slices in deep zone	2	
	Sub-surface Point		
10	Sub-Surface pressure	2	1 cBar
11	Sub-Surface temperature	2	1 m°C
12	Sub-Surface salinity	2	1mPSU
13	Sub-surface C1PHASE	2	0,002°
14	Sub-surface C2PHASE	2	0,002°
15	Sub-surface Optode Temperature	2	1 m°C
	Grounding		
16	Grounding number	1	
17	1st Grounding pressure	2	1 dBar
18	1st Grounding day relative to cycle beginning	1	1 day
19	Hour at 1st grounding	2	1 min
20	1st grounding phase	1	ER:2, DescPd:3, Parkdrift:4, descPp:5, driftPp=6
21	number of ev activations before 1st grounding detection	1	
22	2nd Grounding pressure	2	1 dBar
23	2nd Grounding day relative to cycle beginning	1	1 day
24	Hour at 2nd grounding	2	1 min
25	2nd grounding phase	1	ER:2, DescPd:3, drift:4, descPp:5, driftPp=6
26	number of v activations before 2nd grounding detection	1	
	Emergency ascent		

27	Emergency ascent number	1	
28	1st Emergency ascent time	2	1 min
29	1st Emergency pressure	2	1 dBar
30	number of pump actions in emergency ascent	1	
31	1st Emergency ascent relative day (to 1st cycle day)	1	1 day
	Various		
32	Pump actions before float begins ascent	1	
33	Speed at grounding detection	1	1 cm / s
34	Internal vaccum at ascent start-up	1	5 mbars
35	Last reset Hour : HH	3	1 sec
36	MM		
37	SS		
38	Last reset date : JJ	3	
39	MM		
40	AA		
41	Not used	1	
42	Ice detection flag (1: ISA, 2: satellite visibility, 4: ascent hanging) (added in packet from firmware version 5608A13 & following)	1	
	Complement		
43	Complement (filled by zeros)	44	
	TOTAL	**100**	**bytes**

Table 6 - Technical message n°2

- Tech. Param #6, #10, #11, #12, #24, #25, #35, #36 of tech. Msg 1 and #18, #23, #27 of tech. Msg 2 : all these time are expressed in minutes in the day since midnight.

6.3.1 General information

- Tech. Param #1 of tech. Msg : The prelude phase and the first deep cycle are numbered 1.
- Tech. Param #38 & #60 of tech. Msg 1: Floats' time is expressed with 3 bytes : Hour (1 byte) + Minute (1 byte) + seconds (1 byte).
- Tech. Param #40 of tech. Msg 1 : Pressure sensor offset is measured at the surface. Least significant bit = 1 cbar (two's complement coded). Range: -32 cbar to +31 cbar
- Tech. Param #41 of tech. Msg 1 : Internal pressure is measured at the end of the ascent and before the mission start. Least significant bit = 5 mbar.

6.3.2 Buoyancy reduction

- Tech. Param #8 of tech. Msg 1 : Number of solenoid valve actions at the surface until the crossing of the 8 dbar threshold is an integer from 1 to 255 (modulo 256).

6.3.3 Descent to parking depth

- Tech. Param #11 of tech. Msg 1 : Float first stabilisation time after the crossing of the 8 dbar threshold.

- Tech. Param #13 of tech. Msg 1 : Number of solenoid valve actions carried out to reach the target pressure after crossing the 8 dbar threshold.
- Tech. Param #15 of tech. Msg 1 : Float first stabilisation pressure after crossing the 8 dbar threshold is coded in 8 bits with least significant bit = 1 bar.

6.3.4 Drift at parking depth

- Tech. Param #20 & #21 of tech. Msg 1 : Minimum and maximum pressure collected during the hydraulics measurements at parking depth, expressed in bar.

6.3.5 Drift at profile depth

- Tech. Param #33 & #34 of tech. Msg 1 : Minimum and maximum pressure collected during the hydraulics measurements at profile depth, expressed in bar.

6.3.6 Ascent

- Tech. Param #36 of tech. Msg 1 : Time at the end of the pump action after surfacing, just before the transmission starts.

  Ascent end time (crossing of the 1 bar threshold) occurs approximately [10 minutes + duration of the last pump action of the buoyancy acquisition phase (PT4)] before transmission start time.
- Tech. Param #37 of tech. Msg : Number of pump actions in ascent (from the profile pressure until the crossing of the 1 bar threshold).

6.3.7 Data information

- Tech. Param #4 of tech. Msg 2 : Includes the sum of the data sampled in the shallow and the intermediate zones.
- Tech. Param #5 of tech. Msg 2 : Includes the sum of the data sampled in the deep zones.

6.3.8 Sub-surface point

The sub-surface point is the last ‘raw’ CTD measurement sampled before the switch off of the CTD pump.

- Tech. Param #9 of tech. Msg 2 : Pressure of the sub-surface point, coded in two’s complement (in cbar).

To decode the transmitted (Pssp) value: Pressure (dbar) = [two’s-complement of a 16 bits value (Pssp)] / 10.

- Tech. Param #10 of tech. Msg 2 : Temperature of the sub-surface point, coded in two’s complement (in m°C).

To decode the transmitted (Tssp) value: Temperature (°C) = [two’s-complement of a 16 bits value (Tssp)] / 1000.

- Tech. Param #11 of tech. Msg 2 : Salinity of the sub-surface point coded in m°PSU.

To decode the transmitted (Sssp) value: Salinity (PSU) = Sssp / 1000.

6.4 Descent Profile CTD message (type = 1)

Data	Format	Resolution
Type (=1)	1	1
Cycle number (added from firmware version 5608A11 & following)	2	1
Date of the first CTDO sample: Hours (2 bytes) Minutes (1 byte) Seconds (1 byte)	4	1 hour 1 minute 1 second
1st CTD sample		
Pressure	2	0.1 dBar
Temperature	2	0.001°C
Salinity	2	1 mPSU
2nd CTD sample		
Pressure	2	0.1 dBar
temperature	2	1 m°C
Salinity	2	1 mPSU
3rd CTD sample		
…	…	
15th CTD sample		
Pressure	2	0.1 dBar
Temperature	2	1 m°C
Salinity	2	1 mPSU
complement		
Complement	5	
TOTAL	100	

Table 7 - Descent CTD message

The date of the first CTD sample is relative to the mission start day (float internal day number = 0).
The first 2 bytes provide the number of hours elapsed since mission start day.
The following byte provides the number of minutes and the last byte the number of seconds.

Pressure is coded in two's complement (in cbar) with an offset of -30000 cbar

The Pn transmitted value can then be decoded with the equation:

Pressure (dbar) = { [two's-complement of a 16 bits value (Pn)] +30000 } / 10.

Temperature is coded in two's complement (in m°C).

The Tn transmitted value can then be decoded with the equation:

Temperature (°C) = [two's-complement of a 16 bits value (Tn)] / 1000.

Salinity is coded in mPSU with an offset of -10 000 mPSU.

The Sn transmitted value can then be decoded with the equation:
Salinity (PSU) = (Sn + 10 000) / 1000.

6.5 Submerged drift CTD message (type = 2)

Identical to Descent profile CTD message with **type 2**

6.6 Ascent profile CTD message (type = 3)

Identical to Descent profile CTD message with **type 3**

6.7 Near Surface CTD message (type = 13)

Identical to descent profile CTD message with **type 13**

Float will transmit MC31 * 60 / MC30 measure for “Near surface” acquisition with a limit of 3 packets.

6.8 In Air CTD message (type = 14)

Identical to descent profile CTD message with **type 14**

Float will transmit MC31 * 60 / MC30 measure for “In Air” acquisition with a limit of 3 packets.

6.9 Descent profile CTDO message (type = 8)

Data	Format	Resolution
Type (=1)	1	1
Cycle number (added from firmware version 5608A11 & following)	2	1
Relative day	4	
Hour (hh) (2 bytes)		1 hour
Minute(mm) (1 byte)		1 min
Seconds (ss) (1 byte)		1 sec
1st CTD sample		
Pressure	2	0.1 dBar
temperature	2	0.001°C
Salinity	2	1 mPSU
C1Ph	2	0.002°
C2Ph	2	0.002°
Optode Temp	2	0.001°C
2nd CTD sample		
…	…	
7th CTD sample		
Pressure	2	0.1 dBar
Temperature	2	1 m°C
Salinity	2	1 mPSU
C1Ph	2	0.002°
C2Ph	2	0.002°
Optode Temp	2	0.001°C
complement		
Complement	11	
TOTAL	100	

Table 8 - Descent CTDO message

The date of the first CTD sample is relative to the mission start day (float internal day number = 0).
The first 2 bytes provide the number of hours elapsed since mission start day.
The following byte provides the number of minutes and the last byte the number of seconds.

Pressure is coded in two’s complement (in cbar) with an offset of -30000 cbar

The Pn transmitted value can then be decoded with the equation:

Pressure (dbar) = { [two’s-complement of a 16 bits value (Pn)] +30000 } / 10.

Temperature is coded in two's complement (in m°C).

The Tn transmitted value can then be decoded with the equation:

Temperature (°C) = [two's-complement of a 16 bits value (Tn)] / 1000.

Salinity is coded in mPSU with an offset of -10 000 mPSU.
The Sn transmitted value can then be decoded with the equation:
Salinity (PSU) = (Sn + 10 000) / 1000.

C1 and C2 phases are coded with a 0.002° resolution and an offset of 40°.
The CPn transmitted value can then be decoded with the equation:
C1/C2Phase (angular degree) = [(CPn - 20 000) x 2] / 1000.

Optode temperature is coded in m°C with an offset of 5 000 m°C. The OTn transmitted value can then be decoded with the equation: Optode temperature (°C) = (OTn + 5 000) / 1000.

6.10 Submerged Drift CTDO message (type = 9)

Identical to Descent profile CTD message with **type 9**

6.11 Ascent profile CTDO message (type = 10)

Identical to Descent profile CTD message with **type 10**

6.12 Near Surface CTDO message (type = 11)

Identical to descent profile CTD message with **type 11**

Float will transmit MC31 * 60 / MC30 measure for "Near surface" acquisition with a limit of 3 packets.

6.13 In Air CTDO message (type = 12)

Identical to descent profile CTD message with **type 13**

Float will transmit MC31 * 60 / MC30 measure for "In Air" acquisition with a limit of 3 packets.

6.14 CTD data treatment details

Before transmission, all data have to be treated. Depending on sampling period, number of acquired raw data per profile could be too high for good Transmission. So raw data are treated with following strategy : Operation to convert raw data (CTD or CTDO samples) to "treated data" (CTD or CTDO data to transmit) consist in 2 successive operations to raw data : **Decimation & averaging** depending on **zone & Slice thickness**

6.14.1 Zone & Slice thickness

User can define 3 zones with Threshold & Specific Slice Thickness (mission commands).

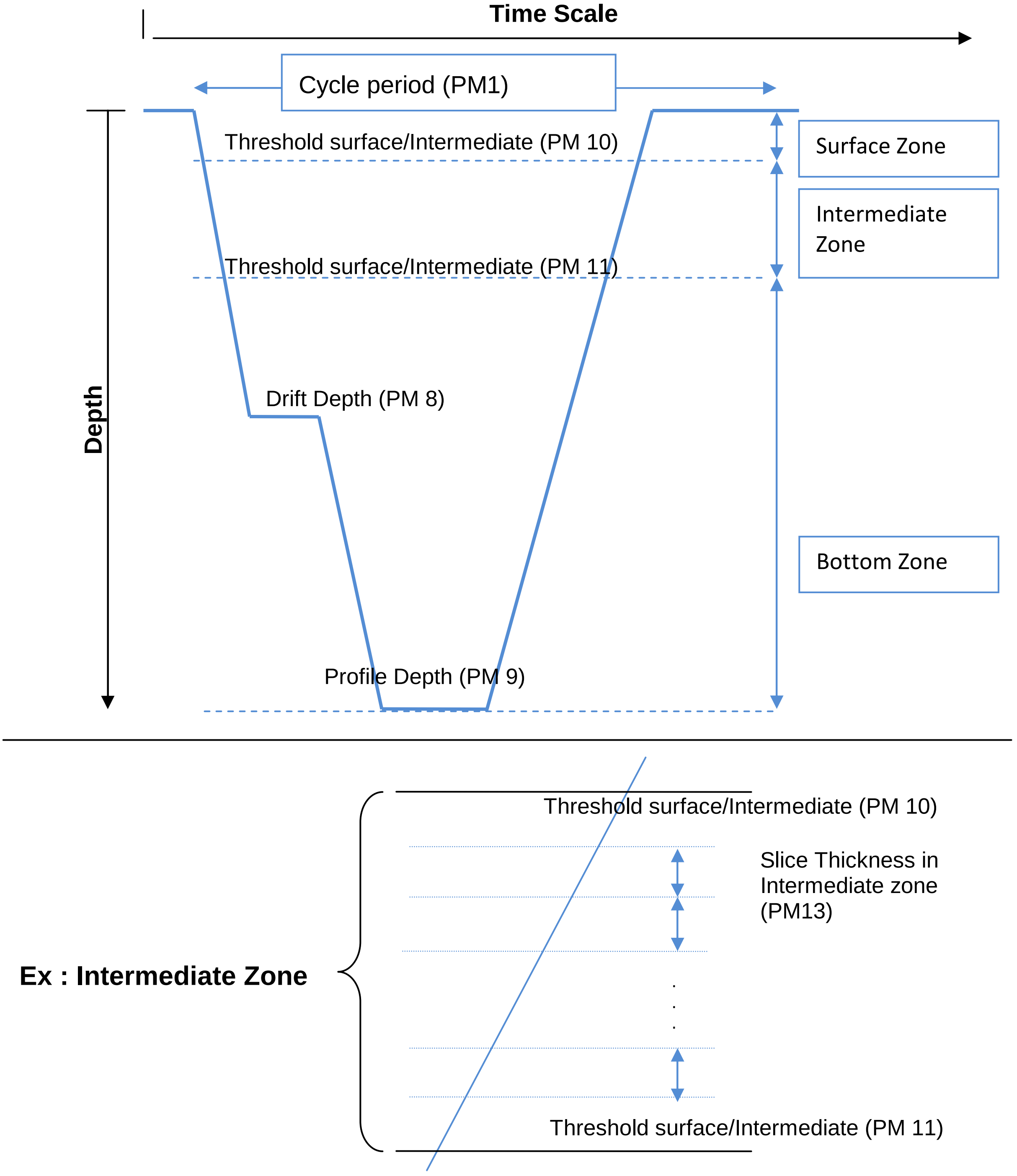


Figure 9- Zone & Slice thickness description

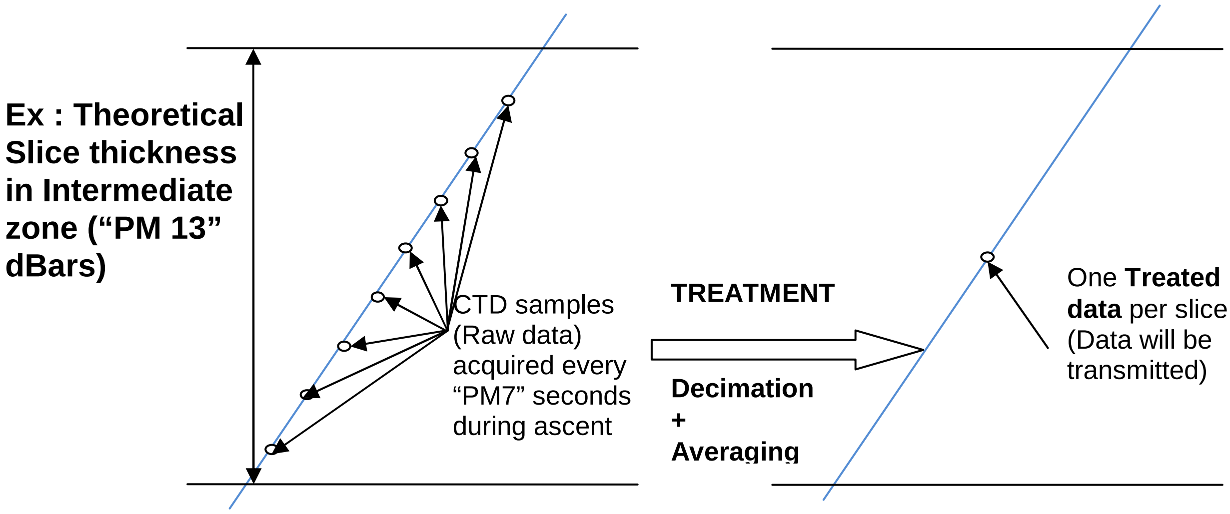


Figure 10 - Treatment description

6.14.2 Decimation

All raw data included in one theoretical CTD slice (defined with mission command depending on zone threshold and slice thickness in each zone) are filtered before proceed to averaging operation. Filter condition is that CTD samples must have 0.5 dBar pressure variation with last kept CTD sample sample to be kept.

Example : 5 dBar slice thickness in bottom zone (defined with PM14) from 20 to 15 dBar.

Only PTS measurements are provided in this example (the decimation algorithm is the same for CTD and CTDO samples).

CTD sample rank	CTD sample Pressure (raw data) in theoretical slice	CTD sample temperature	CTD sample salinity	Last previous Kept sample pressure	Pressure difference with previous sample	Keep after decimation
0	19.9 dBars	17.312	33900	-	-	Yes (1st sample in slice)
1	19.3 dBars	17.314	33901	19.9	19.9–19.3 = **0.6**	Yes
2	18.9 dBars	17.317	33903	19.3	19.3–18.9 = 0.4	No
3	18.6 dBars	17.319	33904	19.3	19.3–18.6 = **0.7**	Yes
4	18.1 dBars	17.320	33905	18.6	18.6–18.1 = **0.5**	Yes
5	17.5 dBars	17.320	33906	18.1	18.1–17.5 = **0.6**	Yes
6	17.1 dBars	17.322	33907	17.5	17.5–17.1 = 0.4	No
7	16.5 dBars	17.329	33909	17.5	17.5–16.5 = **1.0**	Yes
8	16.1 dBars	17.338	33910	16.5	16.5–16.1 = 0.4	No
9	15.6 dBars	17.351	33910	16.5	16.5–15.6 = **0.9**	Yes
10	15.1 dBars	17.361	33913	15.6	15.6–15.1 = **0.5**	Yes

Table 9 - Decimation example

6.14.3 Averaging

All CTD samples kept after decimation are averaged according to slice thickness (zone and thickness) to create a "Treated Data". All the treated Data will be transmit by Iridium.

In our example, following sample pressure will be averaged :

19.9, 19.3, 18.6, 18.1, 17.5, 16.5, 15.6 & 15.1

CTD pressure for treated data is : 18.1375 dBar

Transmitted pressure will be **18.1 dBar**.

CTD temperature sample will be averaged :

17.312, 17.314, 17.319, 17.320, 17.320, 17.329, 17.351, 17.361

CTD temperature for this treated data is : 17.3285 °C

Transmitted pressure will be **17.328 °C**.

CTD salinity sample will be averaged :

33900, 33901, 33904, 33905, 33906, 33909, 33910, 33913

CTD temperature for this treated data is : 33906 mPSU

Transmitted pressure will be **33906 mPSU**.

CTDO phases and Optode temperature samples are processed similarly.

6.15 Programmation message 1 (type = 5)

This message contains float's mission and technical parameters

Data	Format (bytes)	Resolution
Type (=5)	1	
General information		
Float's time (hh+mm+ss, 1 byte each)	3	
Float's date (dd+mm+yy, 1 byte each)	3	
Cycle number	2	1 cycle
Mission parameters – Next Cycle		
Number of Cycles (PM 0)	2	
Cycle Period (PM 1)	1	Days
Reference Day (PM 2)	1	Hours
Estimated time at the surface (PM 3)	1	Hours
Delay Before Mission (PM 4)	0	Minutes
Descent Sampling Period (PM 5)	1	Seconds
Drift Sampling Period (PM 6)	1	Hours
Ascent Sampling Period (PM 7)	1	Seconds
Drift Depth (PM 8)	2	dBar
Profile Depth (PM 9)	2	dBar
Threshold surface/Intermediate Pressure (PM 10)	2	dBar
Threshold Intermediate /bottom Pressure (PM 11)	2	dBar
Thickness of the surface slices (PM 12)	1	dBar
Thickness of the intermediate slices (PM 13)	1	dBar
Thickness of the Bottom slices (PM 14)	1	dBar
Iridium End Of Life transmission period (PM 15)	2	Minutes

Iridium 2nd session waiting time (PM 16) ("0" means no 2nd session)	2	Minutes
Wait at surface after grounding (PM 17)	1	Minutes
Technical Parameter – Next Cycle		
Max eV activation on Surface (PT 0)	1	10 cs
Max volume eV during descent and repositionning (PT 1)	1	1 cm3
Max duration pump during repositionning (PT 2)	1	10 cs
Duration pump during ascent (PT 3)	1	10 cs
Duration Pump during for surfacing (PT 4)	1	1000 cs
Pressure Delta for positionning (+/-) (PT 5)	1	1 dBar
Max pressure before emergency ascent (PT 6)	2	1 dBar
1st threshold for buoyancy reduction (PT 7)	1	1 dBar
2nd threshold for buoyancy reduction (PT 8)	1	1 dBar
Repositionning threshold (PT 9)	1	-
Grounding mode (PT10)	1	
Max volume before detecting grounding (PT 11)	1	1 cm3
Grounding pressure (PT 12)	2	10 dBar
Grounding switch pressure (PT 13)	1	
Pressure delta during drift (+/-) (PT 14)	1	1 dBar
Not Used (PT 15)	1	-
T_profil_alten (PT 16)	1	-
P_profil_alterne (PT 17)	2	1 Bar
Average descent speed (PT 18)	1	1 mm/s
Pressure increment (PT 19)	1	1 dBar ?
PCutoff CTD pump sensor (PT 20)	1	1 dBar
Oxygen measurement (PT 21)	1	
Ascent End Pressure (PT 22)	1	1 dBar
Average ascent speed (PT 23)	1	1 mm/sec
Float ascent speed control period (PT 24)	1	1 min
Pressure ascent speed control pressure (PT 25)	1	1 dBar
Float descent speed control period (PT 26)	1	1 min
Pressure descent speed control pressure (PT 27)	1	1 dBar
GPS retries (PT 28)	1	
Hydraulic message transmission (0 : no, 1 ; yes) (PT 29)	1	
In air acq.: Sampling period (PT 30) (added in packet from firmware version 5608A11 & following)	2	1 second
In air acq.: Acquisition duration (PT 31)	2	1 minute
In air acq.: Duration of pumping at surface (PT 32)	1	100 sec
In air acq.: Periodicity of in air measurement (PT 33)	1	
Coeff A (PT 30) (PT 34)	2	*0,001
Coeff B (PT 31) (PT 35)	2	* (-1)
Complement		
Complement (filled by zeros)	14	
TOTAL	100	

Table 10 - Parameters message

6.16 Hydraulic message (type = 6)

These packets contains all information regarding hydraulic activity during the cycle.

Data	Nb bytes	Resolution
Type (=6)	1	
General information		
Cycle number	2	
Cycle beginning relative day	2	1 day
Cycle beginning hour	2	1 min
Actions during cycle		
Hydraulic action #1: type (0: valve, 1: pump)	1	
Hydraulic action #1: hour (relative to cycle beginning)	2	1 min
Hydraulic action #1: pressure (two's complement coded)	2	1 dbar
Hydraulic action #1: duration	2	1 cs
Following hydraulic actions (up to 12)	7*12	
Not used (filled by zeros)	2	
TOTAL	**100**	

6.17 Programmation message 2 (type = 7)

This kind of packet is introduced from firmware version 5900A03 and following.

Data	Nb bytes	Resolution
Type (=7)	1	
General information		
Float's time (hh+mm+ss, 1 byte each)	3	
Float's date (dd+mm+yy, 1 byte each)	3	
Cycle number	2	1 cycle
Ice detection parameters – Next cycle		
Number of days without surface emergence if ice detected (PG 0)	2	1 day
Number of days before surface emergence even with ice detected (PG 1)	2	1 day
Number of detections to confirm ice at surface (PG 2)	1	1 detection
Start pressure detection (PG 3)	1	1 dBar
Stop pressure detection (PG 4)	1	1 dBar
Temperature threshold (PG 5)	2	0.001°C
Slowdown pressure threshold (PG 6)	2	1 dBar
Pressure acquisition period during ascent (slow speed), once P < PG6 (PG 7)	1	1 minute
Pressure delta min before pump action (PG 8)	1	1 dBar
Pump action duration (PG 9)	2	0.01 second
GPS timeout (PG 10)	1	1 minute
1st iridium lock timeout (PG 11)	1	1 minute

Delay before ascent blocking detection (PG 12)	1	1 minute
Pressure variation for buoyancy inversion (PG 13)	1	1 dBar
Volume of valve action volume for buoyancy inversion (PG 14)	1	1 cm3
Max volume before grounding detection (while in buoyancy inversion phase) (PG 15)	2	1 cm3
Not used (filled by zeros)	69	
TOTAL	**100**	

6.18 Life Expiry message

Life expiry messages are transmitted when the float is drifting on the surface and has completed transmission of all data from the last cycle of the session. Life Expiry mode continues until the recovery of the float or depletion of the battery.

The live expiry message is a technical message type 0

These transmissions - unlike other transmissions - occur at “PM15” minutes intervals. The content of the life expiry message is identical to the technical message. This period can be set up to 7200 minutes max (5 days). Minimum recommended value is 5 minutes (only for recovery operations). Period can be set to short period during recovery operations with great care to cost transmission. To reduce float’s transmission during End-Of-Life, this period can be set to high value to decrease transmission cost.

6.18.1 *Phase description*

Phase indication included in all kind of Iridium messages

Phase nb	Phase Name	Description
0	Pre-mission	Mission beginning (1st Iridium session)
1	Restoffset	Float send “restoffset” command to CTD SBE41 Sensor
2	Buoyancy reduction	Float descending phase at surface (up to PT specific threshold)
3	Descent to parking pressure	Float descend to Parking Pressure depth
4	Parking Drift	Float drift at Parking Depth
5	Descent to profile pressure	Float descend to Profile Depth
6	Drift at Profile Depth	Float drift at Profile Depth
7	Ascent Profile	
8	Satellite transmission	Float transmit all sensor and technical packets
9	Near Surface	“Near surface” measurement before float retrieve max buoyancy
10	In Air	“In air” measurement after float retrieve max buoyancy

Table 11 - Phase Number Description

6.19 Iridium commmands

Each mission or technical parameter can be modified with Iridium telecommand. One parameter can be modified with on telecommand. Several telecommands can be send for one cycle.

PM(16) Inter-cycles wait period (min) : User send telecommand that initialize PM16. At each cycle, float's wait on surface for PM16 values (minutes). This parameter can be set to zero. Once wait is ended, float check if a new telecommand has been sent. If yes, new mission parameter is set with transmitted value and float wait corresponding time. In other case, float begin cycle.
At following cycle, if none telecommand is sent, float waits programmed value (PM16) by last telecommand.
Telecommand has effect on all cycle.

Technical and mission parameters : new parameters are recovered at each cycle (if telecommand has been sent).
So, each new parameter transmitted by telecommand is applied for following cycle.

6.19.1 Telecommand SBD File creation

SBD file, can be created with a text editor (notepad, wordpad, …).

One file contains one command, followed by carriage return ("Enter" : ↵).

Example : to modify cycle period to 5 days, write following command in text file

!PM 1 5<CR> <CR> means carriage return (↵)

Then, save file, close, and change file extension from ".txt" to ".sbd". File is now ready to be send by email (see paragraph 6.19.2).

6.19.2 Sending an SBD Message (telecommand) to the 9602-LP

Messages can be sent to the 9602-LP via SBD from almost any e-mail program (Outlook, Outlook Express, etc.).

1. In order to send e-mail messages to a 9602-LP, the e-mail program must use the standard Multipurpose Internet Mail Extensions (MIME) Base64 encoding as defined in RFC 2045. The following instructions describe how to set this up for Microsoft Outlook Express:

a. Select —Tools/Options

b. Click the —Send|| Tab

c. Under —Mail Sending Forma, click —HTML Settings…

d. Click MIME

e. Select —Base 64 for Encode text using

f. Click OK

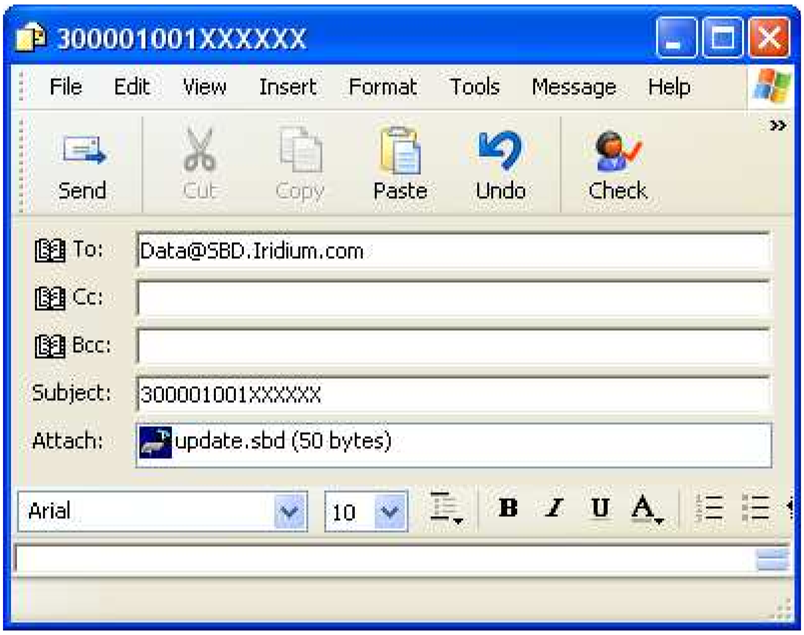
g. Under —Mail Sending Format, click —Plain Text Settings…

h. Repeat steps d – f

2. Send all e-mail messages to Data@SBD.Iridium.com

3. Place the IMEI number of the 9602-LP in the subject line

4. The message should be carried in an attachment, which must have a —.sbd extension



In a delay of a few minutes, user can check that iridium system send confirmation that message is queued (email coming from sbdservice@sbd.iridium.com with subject : "SBD Mobile Terminated Message Queued for Unit : xxxxxxxxxxxxxxx   (here xx replace IMEI number)

Mail from iridium will indicate :

"*The following mobile-terminated message was queued for delivery:*

IMEI: 3000001001xxxxxx
Time: Thu Apr 29 12:00:13 2010

Attachment Filename: update.sbd
Attachment Size: 10

The MTMSN is 2, and the message is number 1 in the queue."

At this step, message is queued and ready to be treated by float at next float surfacing.

Important : Telecommand file size must be <u>less than 30 bytes</u>

7 SPECIFICATIONS

- Storage

Temperature range...-20°C to +50°C
Storage time before expiry ....up to 1 year

- Operational

Temperature range... 0°C to +40°C
Pressure at drift depth .... 40 bar to 412 bar
Depth maintenance accuracy .... ± 3 bar typical (adjustable)
Survival at sea ....up to 5 years
Maximum number of cycles..up to 150 cycles

- Mechanical

Length
with antenna ....#219 cm
Diameter
casing ....15 cm
damping disk ....25 cm
Weight..26 kg

- Sensors

Salinity
range.. 10 to 42 PSU
initial accuracy .... ± 0.005 PSU
resolution.. 0.001 PSU
Temperature
range... .... -3°C to +32°C
initial accuracy ....± 0.002°C
resolution...0.001°C
Pressure
range... .... 0 bar to 7000 dbar
initial accuracy .... ± 2.4 dbar*
resolution...0.1 dbar
Offset adjusted when surfacing

Oxygen (C1Phase, C2Phase & temperature)
Range (C1Phase, C2Phase).. -40.000° to 90.000°
initial accuracy .... 0.001°
Range (Temperature)... -5.000° to 60.000°
initial accuracy .... 0.001°

(*) offset has to be adjusted at each surfacing

8 ARVOR-DEEP OPERATING PRINCIPLE

Movement of the float through its profile is accomplished by a pump and valve system. The pump transfers oil from the inner reservoir to the outer bladder. Oil moves back to the reservoir when the valve is opened- -driven by the difference between the float's internal and external pressures.

The float's speed of ascent oscillates. This oscillation is due to the way in which the float's controller regulates its speed. The controller, using depth measurements from the float's pressure sensor, calculates the change in depth over a set period of time. With this information, the controller determines the float's speed.

When ascending, if the calculated speed is lower than desired, the pump is activated for about 10 seconds, pumping oil into the outer bladder. This produces an increase in buoyancy, which increases the speed of ascent.

As the float rises to shallower depths, its buoyancy decreases, causing the ascent speed to also decrease. When the calculated speed is too low, the pump is activated again.

This cycle repeats until the float reaches the surface.

The same regulating method is used to control the float's descent speed, by opening the valve and allowing oil to flow from the external bladder to the internal reservoir.

Why does ARVOR-DEEP's speed decrease as it ascends?

The buoyancy of a float is determined principally by its mass and its volume, but another factor, hull compressibility, also plays an important role. As ARVOR-DEEP ascends, the decrease in water density reduces the float's buoyancy. At the same time, the decrease in water pressure causes ARVOR-DEEP's hull to expand, which increases the float's buoyancy. The two effects tend to counteract each other.

Because ARVOR-DEEP's compressibility is actually less than that of sea water, the decrease in buoyancy due to decreasing water density is greater than the increase in buoyancy due to hull expansion. This causes ARVOR-DEEP's speed of ascent to decrease as it rises in the water column.

Conversely, as the float descends, the increasing water density increases the buoyancy more than the decreasing buoyancy from hull compression. This causes ARVOR-DEEP's speed of descent to slow as it goes deeper.

To reduce the probability of contact with ships, ARVOR-DEEP's target speed during the initial stage of descent is high at shallow depths. This minimizes the time during which the float is at risk of damage.

To slow the float's descent, its controller is programmed with a series of depths at which the descent speed is halved until it reaches the target depth.

9 LITHIUM BATTERY

All batteries, both lithium batteries and batteries with other chemical elements, contain large quantities of stored energy. This is, of course, what makes them useful, but it also makes them potentially hazardous.

If correctly handled, neither alkaline nor lithium batteries present any risk to humans or the environment. Improper handling of these batteries presents potential risks to humans, but does not present an environmental risk.

The energy stored in a battery cell is stored in chemical form. Most batteries contain corrosive chemicals. These chemicals can be released if the cells are mishandled. Mishandling includes:

- short-circuiting the cells;
- (re)charging the cells;
- puncturing the cell enclosure with a sharp object;
- exposing the cell to high temperatures.

WARNING: BOTH ALKALINE AND LITHIUM BATTERIES MAY EXPLODE, PYROLIZE OR VENT IF MIS-HANDLED. DO NOT DISASSEMBLE, PUNCTURE, CRUSH, SHORT-CIRCUIT, (RE)CHARGE OR INCINERATE THE CELLS. DO NOT EXPOSE CELLS TO HIGH TEMPERATURES.

The lithium thionyl chloride cells used in ARVOR-DEEP floats incorporate sealed steel containers, warning labels and venting systems to guard against accidental release of their contents.

WARNING: IF A BATTERY SPILLS ITS CONTENTS DUE TO MISHANDLING, THE RELEASED CHEMICALS AND THEIR REACTION PRODUCTS INCLUDE CAUSTIC AND ACIDIC MATERIALS, SUCH AS HYDROCHLORIC ACID (HCL) IN THE CASE OF LITHIUM THIONYL CHLORIDE BATTERIES, AND POTASSIUM HYDROXIDE (KOH) IN THE CASE OF ALKALINE BATTERIES. THESE CHEMICALS CAN CAUSE EYE AND NOSE IRRITATION AND BURNS TO EXPOSED FLESH.

The hazard presented by these chemicals is comparable to that presented by common domestic cleaning materials like bleach, muriatic acid or oven cleaner.

Inevitably, the battery contents will eventually be released into the environment, regardless of whether the cells are deliberately dismantled or simply disintegrate due to the forces of nature. Because of their highly reactive nature, battery materials disintegrate rapidly when released into the environment. They pose no long-term environmental threat. There are no heavy metals or chronic toxins in ARVOR-DEEP's lithium cells. Indeed, a recommended safe disposal method for thionyl chloride lithium cells is to crush them and dilute them in sufficient quantities of water.

Discharged batteries pose a greatly reduced threat, as the process of discharging them consumes the corrosive chemicals contained in them.

In summary, ARVOR-DEEP's lithium battery poses no significant or long-term environmental threats. Any threats that they do present, are short-term threats to the safety of persons mishandling the cells. These safety threats are similar to those of other common household-use materials. These threats are reduced when the cells are discharged - and exist only if the cells are mishandled in extreme ways. These threats are the same as those presented by the alkaline cells widely used by consumers.

10 GLOSSARY

ARVOR-DEEP
Name given to the drifting profiler developed by **nke** and IFREMER.

BT
Bluetooth

CPU
Central Processing Unit. In the context of ARVOR-DEEP, this term denotes the board that ensures the running and control of the system.

COM1, COM2.
Serial communication ports.

CTD
Celerity (for salinity), Temperature, Depth and Oxygen

dbar.
1/10 bar = 1 decibar Unit of pressure used for ARVOR-DEEP. It roughly corresponds to a depth of 1m.

IFREMER
Institut Français pour la Recherche et l'Exploitation de la MER (French Institute for the Research and the Exploitation of the Sea).

Mission
The portion of ARVOR-DEEP's life that consists of a number of repeating cycles of descent, submerged drift, ascent and data transmission.

PC
Personal Computer; IBM-PC compatible.

PM
Mission Parameters set

RS232
Widely recognized standard for the implementation of a serial data communication link.

Triplet
Set of four measurements (Salinity, Temperature, Depth and dissolved oxygen) all taken at the same time.

VT52, VT100
Video Terminal, type 52 or 100
Computer terminals developed by Digital Equipment Corporation (DEC). They are considered standard in the field.

11 ANNEX A: DETERMINATION OF CYCLE TIMINGS

11.1 Float clock offset determination

Over time, the float's clock may drift. Clock drift can be defined as the drift of the clock in hours/ minutes/ seconds per year. To correct for this, we must apply a clock offset where clock offset is defined as a measurement, done at a given time, of the offset of the clock due to clock drift. Thus a clock offset should be estimated for each cycle and used to correct cycle timings provided by the float.

Float clock offset is defined as: **Float clock offset = Float time - UTC time**.

As PROVOR-DO-I sets its Real Time Clock (RTC) before each transmission phase, the clock offset, which is the drift of the RTC for the cycle duration only, can be neglected. **Float clock offset = 0.**

11.2 Cycle timings determination

The hours and minutes of the cycle timings are obtained from technical message information.

The associated day can be obtained by the following algorithms.

The day of Transmission Start Time (TST) is determined using the time of the first received Iridium message (FMT):

1. Convert FMT in Float Time (FMT_{FT} = FMT + *FloatClockOffset*),
2. Convert the hours and minutes of FMT_{FT} in Technical Message time (in minutes after truncation) to obtain FMT_{FTTM},
3. Compare the resulting FMT_{FTTM} with TST to determine the day of TST (remembering that $FMT_{FTTM} \geq TST$).

The day of Ascend End Time (AET) is determined using TST.

The day of Ascent Start Time (AST) is determined using AET and the assumption that: AET-AST < 24 h.

The day of Deep Park Start Time (DPST) is determined using AST and the assumption that: AST- DPST < 24 h.

The day of Park End Time (PET) is determined using DPST and the assumption that: DPST - PET < 24 h.

The day of Cycle Start Time (CST) is determined using a Reference Date (RD) which can be:

- For cycle #1 (first deep cycle): the day of the first descent (determined from float startup date + PM4),
- For a given cycle #N (N > 1):
  - If cycle #N-1 exists: RD is the time of the last received Iridium message (LMT) of the cycle #N-1,
  - Otherwise, RD is computed from LMT: RD = LMT – CycleDuration (PM1).

The obtained RD is then used to determine the day of CST:

1. Convert RD in float time (RD_{FT} = RD + *FloatClockOffset*),
2. Convert the hours and minutes of RD_{FT} in Technical Message time (in minutes after truncation) to obtain RD_{FTTM},
3. Compare the resulting RD_{FTTM} with CST to determine the day of CST (remembering that $RD_{FTTM} \leq CST$).

The day of Descent Start Time (DST) is determined using CST.

The day part of First Stabilization Time (FST) is determined using DST and the assumption that: FST-DST < 24 h.

The day part of Park Start Time (PST) is determined using FST and the assumption that: FST- PST < 24 h.

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